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ENGINEER DEPARTMENT, U. S. ARMY.

REPORT

UPON

UNITED STATES GEOGRAPHICAL SURVEYS

WEST OF THE ONE HUNDREDTH MERIDIAN,

IN CHARGE OF

CAPT. GEO. M. WHEELER,

CORPS OF ENGINEERS, U. S. ARMY,

UNDER THE DIRECTION OF

THE CHIEF OF ENGINEERS, U. S. ARMY.

PUBLISHED BY AUTHORITY OF THE HONORABLE THE SECRETARY OF WAR,
IN ACCORDANCE WITH ACTS OF CONGRESS OF JUNE 23, 1874, AND FEBRUARY 15, 1875.

IN SEVEN VOLUMES AND ONE SUPPLEMENT, ACCOMPANIED BY ONE
TOPOGRAPHIC AND ONE GEOLOGIC ATLAS.

VOL. I.—GEOGRAPHICAL REPORT.

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LETTER OF TRANSMITTAL.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., June 1, 1879.

GENERAL: I have the honor to forward herewith manuscript of Volume I, the last of the quarto reports of this office, the publication of which is authorized by acts approved June 23, 1874, and February 15, 1875.

This affords a pleasing opportunity once for all to express my thanks to the large number of assistants, officers, civilians, and others whose genuine enthusiasm for their various tasks has alone made possible the systematic production of so great an amount of geographic, geologic, and other scientific material.

The aid extended by the supply branches of the War Department has added materially to the augmentation of results.

Very respectfully, your obedient servant,

GEO. M. WHEELER,
Captain of Engineers,
In charge.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, United States Army, Washington, D. C.

NOTE.—This report, brought substantially to a close in June, 1879, was not presented for publication until 1887, from press of other duties and subsequent prolonged illness.

INTRODUCTION.

The area within the United States west of the one hundredth meridian of longitude (1,443,360 square miles) embraces, entire, the basins of the Colorado (270,000 square miles), Interior (208,600 square miles), Coast (100,900 square miles), and Sacramento (64,300 square miles); also, that part of the Columbia (215,700 square miles) south of the forty-ninth parallel, and portions of the basins of the Missouri (338,200 square miles), Rio Grande (123,000 square miles), Arkansas (75,500 square miles), Brazos (34,800 square miles), and the Red River of the North (3,360 square miles).

Of the above approximation 993,360 square miles is of a mountainous structure, the many ranges surrounding interior plateaux and valleys, while the remainder (450,000 square miles) is composed of the "mauvaise terre" of the northern," plains" of the interior, and the "staked plains" of the southern, latitudes.

The approximate average elevation above sea of the total area west of the one hundredth meridian is approximately 4,225 feet, the volume of the mass above this level being 1,155,201 cubic miles, while the approximate average altitude of the area of 359,065 square miles covered by the survey is approximately 5,000 feet, or corresponding to a volume of 340,024 cubic miles.

The Colorado, Columbia, Missouri, Rio Grande, Arkansas, Sacramento, Brazos, Pecos, and Red Rivers are the principal lines of drainage of the following approximate total lengths and parts thereof comprised within the above area:

Name of river.	Total length.	Length west of 100th meridian.	Name of river.	Total length.	Length west of 100th meridian.
	Miles.	Miles.		Miles.	Miles.
1. Colorado	1,675	1,675	6. Sacramento	370	370
2. Columbia	1,300	1,250	7. Brazos	770	100
3. Missouri	2,908	1,000	8. Red River	1,200	175
4. Rio Grande	1,800	1,125	9. Pecos	600	600
5. Arkansas	1,500	360			

The Great Interior Basin that, on account of its present state of desiccation, is without outlet to the sea, has its own system of drainage and reservoirs, marked by a number of minor streams, such as the Humboldt, Sevier, Bear, Carson, Walker, Truckee, and Owens Rivers.

The following determined volumes have been noted for the streams given herewith:

No.	Name of river.	Total length, approximated.	Total drainage area, approximated.	Length in area west of 100th meridian.	Navigable west of 100th meridian.	
					To what point.	Miles, approx.
		Miles.	Square miles.	Miles.		
1	Lower or main Mississippi	1,286	1,256,850	0	All east of 100th meridian	0
2	Yazoo	500	12,800	0	Not navigable	0
3	Saint Francis	300	10,500	0	do	0
4	Red	1,200	97,000	175	Not navigable west of 100th meridian.	0
5	Arkansas	1,514	189,000	360	do	0
6	Upper Mississippi	1,330	169,000	0	All east of 100th meridian	0
7	Missouri	2,908	518,000	1,000	To Fort Benton	1,225
8	Columbia	1,300	213,700	1,250	To the Cascades	[illegible]
9	Sacramento	370	24,300	370	Tehama Rapids	[illegible]
10	Colorado of the West	1,675	272,000 (West of 100th meridian.)	1,675	Mouth of Grand Cañon	[illegible]
11	Rio Grande	1,800	125,000	1,125	Not navigable west of 100th meridian.	0

No.	Volumes of discharge.					Remarks.
	By—	Locality.	Date.	Velocity in feet per second.	Discharge per second.	
					Cubic feet.	
1	Humphreys & Abbot				675,000	Physics and Hydraulics of Mississippi River, pages 93 and 94.
2	do				42,000	Physics and Hydraulics of Mississippi River, page 93.
3	do				11,000	Physics and Hydraulics of Mississippi River, page 93.
4	do				57,000	3,000 square miles in area west of 100th meridian; Physics and Hydraulics of Mississippi River, page 93.
5	do				63,000	11,500 square miles in area west of 100th meridian; Physics and Hydraulics of Mississippi River, page 93.
6	do				105,000	
7	do				120,000	1,000 miles to mouth of Three Forks; Physics and Hydraulics of Mississippi River, page 93.

No.	Volumes of discharge.					Remarks.
	By—	Locality.	Date.	Velocity in feet per second.	Discharge per second.	
8	Estimate of Board of Engineers.				Cubic feet. [illegible]	(Grant). Sen. Ex. Doc. No. [illegible], [illegible] Cong., [illegible] sess., page [illegible].
9	W. H. Hall, State engineer of California.	Highest known. Ordinary high flood.	Discharge.	[illegible] cu. ft. [illegible] cu. ft.	(Average.) [illegible]	Steam-boat has reached Red Bluff, [illegible] miles.
10	Lieutenant Bergland	Stone's Ferry	Aug. 11, [illegible]	[illegible]	[illegible]	
	Do.	Camp Mohave	Sept. 3, 1875	1,[illegible]	11,[illegible]	United States Geographical Surveys west of the 100th meridian.
	Do.	Fort Yuma	Mar. [illegible], 1876	[illegible]	7,[illegible]	"
	P. W. Hamel	New Camp Mohave.	Sept. [illegible], 1871	[illegible]	[illegible]	"
	Lieutenant Michler	Mouth Gila River	Dec. —, 1854	[illegible]	[illegible]	Mexican Boundary Survey.
11	L. Nell	[illegible], N. Mex.	Sept. [illegible], 1876	[illegible]	[illegible]	Lower water. United States Geographical Surveys west of the 100th meridian.
	Do.	Fort Selden, N. M.	Oct. 2, [illegible]	[illegible]	[illegible]	"
	Lieutenant Bergland	Del Norte, Colo.	June [illegible], 1877	[illegible]	4,[illegible]	High water. do.

NOTE.—The following measured discharges have been found for minor streams, a part or all of which lie west of the 100th meridian: (1) Kansas River, between Wamego and Saint Mary's, [illegible] cubic feet per second, in September, [illegible], taken at stage of about 4 feet above low water; (2) Yellowstone, at Fort Keogh, near mouth of Tongue River, September, [illegible], [illegible] cubic feet; at same point in October, [illegible], [illegible] cubic feet per second; Willamette, at one-fourth mile below the northern boundary of Portland, in fall of [illegible], at stage of [illegible] to 4 feet above 0 or low water, [illegible] cubic feet per second, average velocity, [illegible] feet per second, and later at [illegible] feet (approximately) above low water, [illegible] cubic feet per second; (4) confluents of Great Salt Lake (Bear, Weber, and Jordan Rivers and miscellaneous), March and April, [illegible], [illegible] cubic feet per second (during rising water and prior to commencement of irrigation); (5) Gunnison, below Tomichi Creek, November 5, [illegible], [illegible] cubic feet per second.

For authority for the above see (1) A. R. C. of E. [illegible], App. O, p. [illegible], J. D. McKown, under Major Suter; (2) A. R. C. of E. [illegible], App. [illegible], p. [illegible], Lieut. Maguire; (3) A. R. C. of E. 1877, App. JJ, p. [illegible], R. A. Habersham, under Major Wilson; (4) A. R. Geographical Surveys, [illegible], App. D, p. [illegible], Lieut. Young; (5) A. R. Geographical Surveys, [illegible], App. A, p. [illegible], Lieut. Bergland.

The backbone of the continent within the boundaries of the United States, or the water-shed between the Interior and Pacific (approximately 1,850 miles in length), consists of a number of distinct ranges separated by noticeable passes easily approached from the eastward or westward, and to which the appellation "Rocky Mountains" has been given.

This name fades away as the true condition of its topography becomes known from actual surveys, and each of the several ranges claims a title.

The mother mass of this water-shed consists of the Saguache and Snowy Ranges in Colorado (about 425 miles in length) that, beginning at the head of the broad San Luis Valley, extend northwardly with a single break or marked depression at the head of the Arkansas, and become lost in the lower levels only as the ridges leading from Long's Peak reach the plains in this direction.

To this group of serrated ridges the name of "Sierra Madre" has been given, and no other mountain mass within our borders so well deserves the title, except perhaps the Sierra Nevada and Cascade Ranges, that within

United States territory are more local in their position, neither do they so truly form part of the great main line of continental uplift extending from the Isthmus of Darien to the Arctic Sea.

To describe the physical characteristics of the multitude of ranges as to their more important topographic relations alone, would fill volumes, and, indeed, even that could not be done for parts of the area that have not yet undergone instrumental survey.

Among the most important are the two just named, the Sierra Nevada, Cascades, Wahsatch, Uintah, Salmon River, Humboldt, Wind River, and many others.

The Coast Ranges of California and Oregon, and the large number of subordinate chains of the Great Basin, and other portions of the elevated plateau aggregate not less than 161 distinct ridges or mountain chains, with serrated axial profile of not less than 20 miles each in length, disposed according to political divisions as follows: Nevada, 49; Arizona, 15; New Mexico, 27; Utah, 25; California, 24; Colorado, 11; Wyoming, 4; Montana, 1; Idaho, 4; Oregon, 1 (part of Cascade Range only); Wyoming, 0; Texas, 0; Nebraska, 0; Dakota, 0; Kansas, 0; and Indian Territory, 0. Total, 161.

Of the above 143 distinct and separately named mountain ranges, distributed as follows: Nevada, 46; Arizona, 12; New Mexico, 25; Utah, 25; California, 20; Colorado, 11; Idaho, 3; and Oregon, 1; total, 143; independent of numbers of isolated groups of mountains as well as plateaux and mesas, have fallen within the area under survey.

Of the groups of named mountains, having no regular trend, there are found 103 within the surveyed area, and 93 exterior; and of the 41 principal plateaux, already named, lying west of the one hundredth meridian, 36 fall within the surveyed limits and 5 without

The aggregate number of ranges, mountain groups and plateaux(not including a number of minor subdivisions, that make up the Great Colorado Plateau) is three hundred and ninety-eight (398).

The ranges, mountains, and plateaux (37, 72, and 5 in numbers, respectively) lying outside the region surveyed, are taken from the names given upon the latest edition of the Western Territory map of the Engineer Department, which number will doubtless be augmented when a detailed instrumental topographic survey of this territory is made.

The great mountain forms, which consist for the most part of upturned and corrugated strata, have been divided into ranges and mountains, the former confined to persistent ridges with distinct axial trend of not less than 20 miles in length each, the latter referring to the groups of mountain masses thrown above the general level with distinctive orographic features.

The plateaux are tabular shaped formations, usually of sedimentary character, although often volcanic capped, standing apart and above the general level, being of irregular form and height, showing usually bold escarpments along at least one well-marked portion of their perimeter.

An attempt has been made to confine where possible the adjective use of the word "Mount" to a single isolated structure, as "Mount Taylor," and attaching names to the summit of the peaks, the latter being a topographical feature, appreciable in extent, susceptible of exact geographical location, and more easily described with a definite individuality.

The passes from east to west are more limited in numbers, and yet the practicable ones for routes by rail or common roads are found to increase upon diligent search, while ranges considered impassable a decade since are now climbed by the narrow-gauge tracks in their search for mining and other markets found in the local objective points of these rugged regions.

The extended plateaux of the Colorado Basin and other localities west of the Continental Divide, and between it and the Sierra Nevada and Cascade Ranges, exceed in dimensions the plateaux and mesa system of Old Mexico, and the dry interior climate at elevations from 3,000 to 7,000 feet and above, south of the 40th parallel, is doubtless as lovely as any of the typical Mexican climes of the high interior valleys, and, when clearly understood as civilization advances, will furnish numerous spots noted for their climatic efficacy.

The Colorado Plateau, first named by the writer in 1868, covers, in its various mountain plateau and mesa forms, at least 100,000 square miles in Utah, Colorado, New Mexico, and Arizona.

The sub-plateaux, defined by the varying uplifts and subsequent denudations, are severally named. Erosion, through the sedimentaries that are the basis of its structure (and of the primitive rocks in some instances), has given rise to the Grand Cañon of the Colorado, a gorge without parallel, so far as known, for its high and nearly perpendicular walls, tortuous windings, and great length. Other cañons of extraordinary magnitude are the Glenn and Uinta of the Colorado River, the "Grand" of the Arkansas, the Cañon of the Yellowstone, while the Colorado, for the greater part of its length, is essentially a cañon river, and the Snake River flows through deep rocky gorges for much of its distance, and minor cañons of varied dimensions are to be found in or along the flanks of every prominent mountain range.

The principal falls are those in and around Yosemite Valley, more noted for their vertical dimensions than those of the Yellowstone, the Great and Little American on Snake River, and certain minor instances along the Columbia and Colorado Rivers.

The Yosemite Gorge has become justly famed as one of the most picturesque, and is especially unique at the season of high water.

The Yellowstone Park (so called) is one of the later wonders, on account of its geysers, mud and thermal springs, waterfalls, and beautiful lakes.

But few of these Western valleys are of erosion, and these comparatively narrow and occupying but a small area. The great detrital, plain-like valleys occupy the interior spaces between the positive ranges and plateaux, while the character of the extended plains, uniform as to elevation, the wrinkles of which are mostly from erosion, extending from the 100th meridian to the base of the mountains, is well known from descriptions of travelers and explorers of all grades.

The deserts (so called) are portions of the Lower Colorado Valley (now crossed by a railroad), the Mohave, Death Valley, Amargosa, Ralston, Humboldt, Quinn's River, and the Snake, thus reaching in patches from the Mexican border to the Columbia, between the meridinal limits of the Wahsatch and Sierra Nevada.

Sand dunes are noted particularly in the Colorado, Death, Amargosa, Termination, and San Luis Valleys.

Numbers of natural parks or extended glades have been discovered in the mountainous portions of Colorado, New Mexico, and Arizona, and especially by the writer in the area embraced by the heads of Little Colorado, Gila, San Francisco, and Salt Rivers.

The name has been erroneously applied in Colorado to those extended systems of detrital valleys inclosed by high encircling ridges called North, Middle, and South Parks, that are not particularly different from similar encompassed valleys, debouching abruptly in the direction of the flow of the waters, but wanting in that apparently artificial distribution of nature's bounties to be found in the glade-like parks above mentioned, and indeed others along the southeastern portion of the Great Colorado Plateau.

The number of peaks between 10,000 feet and 15,000 feet within the entire area, so far as now known, and measured and computed by this office, is (560) five hundred and sixty, Mount Whitney, or Fisherman's Peak, in the Southern Sierras, enjoying an elevation of 14,470 feet (barometric), being the highest that has been carefully measured barometrically. The number both measured and computed by the Survey within the limits between 5,000 feet and 10,000 feet can only be given quite approximately as (882) eight hundred and eighty-two.*

Areas of depression below the level of the sea are found in the Colorado Valley north and west from Fort Yuma, covering a space of approximately 1,600 square miles, and portions of Death Valley, in Eastern California.

The lakes of the Great Interior Basin, acting as reservoirs, are largely saline and alkaline, while the number in other localities is large, especially those little lakes near the crests of important mountain ranges. The most remarkable one, examined and called Crater or Mystic Lake, northwest of Fort Klamath, on the summit of the Cascades, evidently occupies an old eruptive vent, the surface of the water being not less than 900 feet from the lowest point of the rim of a number of lava beds of various colors and separate flows, that constitute the incasing walls of an oval of approximately

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*These represent only a part of all existing peaks, as also but a portion of those determined in altitude. (See Appendix A and special volume Geographic Positions, &c., royal 8°.)

7 by 9 miles. The greatest height of the almost perpendicular wall is about 2,200 feet. A small conical extinct crater of basalt rises out of the western end of the water, which is pure and cool. Although no visible outlet is known, yet one is possible, and the relative elevations permit that streams emerging from beneath the lava beds at both the eastern and western slopes of the Cascades should have their actual sources in this unique reservoir.

The sedimentary strata and crystalline rocks are broken through in many localities by basalts and older lavas, the vent points being marked in some instances by the residual typical cone, great fields of which are noted near San Francisco Mountain in Arizona, while the lines of eruption of the many overlying and intercalated masses of the more ancient lavas is naturally veiled from view.

The areas embraced by these lavas, except the basalts and trachytes, prove in most instances as indexes to deposits of the precious metals where search has been made, and will gradually become the alphabet of the more careful and intelligent prospecting of the future as mining advances into this extensive region.

The high mountain areas, that are perpetually covered with snow, are comparatively slight, and confined to the ravines sheltered from the sun's direct rays. This is due largely to the relatively small amount of rain and snow fall existing at the present stage of desiccation of this portion of the continent, the elevation of many ranges being amply sufficient with proper humid conditions to justify the presence of extensive active glaciers.

The permanent source of supply from glacial masses, so efficacious in rendering certain the plans for irrigation in India and Italy that have the immense snow and ice storehouses of the Himalaya and the Alps, respectively, is wanting in the West; the winter snows melt rapidly and their moisture is soon transmitted below the lower levels, that most require irrigation, hence all plans looking to a successful recuperation of parched lands by the use of water must depend upon a larger than the usual modulus, upon the minimum of the running waters for the season, assuming a safe percentage of the additional volume that may be obtained by storage reservoirs.

Artesian wells may be made to increase the practicably arable areas by appreciable amounts at minor spots, but on no considerable scale.

Observations for the classification of the lands for map delineation into (1) Arable or agricultural, (2) timber, (3) pasturage or grazing, (4) arid or barren, having been conducted over an area exceeding 175,000 square miles in California, Nevada, Idaho, Wyoming, Utah, Colorado, New Mexico, and Arizona, there appears as a result the following approximate percentages: (1) Arable, 4.77 per cent.; (2) grazing, 49.37 per cent.; (3) timber, 26.94 per cent.; (4) arid, 16.95 per cent.; water and marsh, 1.01 per cent.; and chaparral, 0.96 per cent.

The locations of hundreds of points at which the precious and economic minerals occur but substantiate the belief gradually gaining ground of the almost unlimited prospective supply; the development of which is constantly being rendered more economic and certain.

The highest percentage reached for any single sheet by the "arid and barren" is 53.32, while the "arable," although relatively of meager amount (23.83 per cent. being the highest noted), will be increased somewhat by the artificial process of irrigation systematically conducted.

Evidences of extinct glacial action are numerous; and have been noted by observers for periods of years. The detrital floors of many of the valleys are the result of this action, and the detailed shapes of several prominent mountain ranges, especially in Colorado, Utah, New Mexico, and California, have been governed by the grand carving of glacial beds.

A possible connection between the lacustrine beach of the ancient Lake Bonneville, that once covered the present Salt Lake and Sevier Lake Basins entire, and the deep-fluted carvings along the eastern flanks of the Snake Range in Eastern Nevada was observed in 1872, indicating that glaciers existed during the period that portions of the Great Interior Basin were covered by extensive lakes draining toward the Pacific.

Mineral and thermal springs in considerable numbers have been noted in this region, and, up to 1875 not less than 120 had been located and reported upon. (See vol. 3, p. 150.)

The lower levels of the detrital plain-like valleys, more especially of the Great Interior Basin, are marked by alkaline and saline flats, or mud lakes, of many square miles in extent, impassable in seasons of rain and snowfall, and the plague of these desert-like areas in times of drought.

The various sedimentary systems have been made in many localities to give forth their treasures of invertebrates and vertebrates, thus adding new forms and marking a wider distribution of others.

To the paleontologist the vision of still rich fields in which are entombed the remains of the faunal and floral life of the fossil-bearing formations is as attractive as the belief in the hoped-for bonanza to the miner, and somewhat alike; the surface alone has been but skimmed in either regard.

Great additions have been made by the Government and other exploring parties during the past twenty years in the identification and distribution of the living fauna and flora, still there is a vast field for intelligent research into the details of distribution and variations of the multitudinous forms of animal and plant life.

While the geologist has ample room to reduce to a system the rock exposures as well as their origin and history, and the mineralogist to investigate and determine as to their constituents in this area of, approximately, 1,500,000 square miles, possessed of altitudes varying from 200 feet below to nearly 15,000 feet above sea-level, the student of antiquity of the ancient races and their ruins and the present aboriginals has a horizon the value of which is but just dawning upon the popular mind, and from the many monuments marking the habitations of prehistoric peoples must come much to aid in making clear the nature of the pre-aboriginals and their modes and circumstances of life.

The approximate number of Indians (pueblos and nomads) within the area of survey was found to be 60,000, belonging to not less than thirty-three distinct tribes.

The white population therein, approximately, according to the census of 1880, was 631,067, that on account of the rapid influx of miners and an associate population stimulated by constant discoveries of gold and silver, and ever increasing railroad facilities, will doubtless be at least doubled in the enumeration of 1890.

Of the different industries, mining takes the lead, except in the States of California and Oregon, where agriculture has reached a distinctive status.

The commercial relations are principally of mining necessities toward the interior, agricultural products toward the coast, and transcontinental traffic by the Pacific railways.

The future principal *loci* of the fixed industries of the entire country, no matter to what point the center of population may drift, are, for agriculture, the empire of the broad drainage of the Mississippi Valley entire; for commerce, at or near the principal harbors of the Atlantic and Pacific coasts, the Gulf of Mexico, the great lakes, together with a number of *entrepot* points on the main navigable streams; for manufactures, mainly in the valleys leading to the Atlantic and Pacific, north of latitude 40 degrees; while mining for the precious metals belongs more particularly to the mountainous area of nearly 1,000,000 square miles of the western, or Pacific coast slope, with exceptional localities in the Apalachian region.

The great Mississippi Valley may be made the home of not less than 200,000,000. Millions more can find a reward for industry in the area from the eastern base of the Continental Divide to the Pacific, while the comparatively narrow belt called the "Atlantic Districts" (see sketch map accompanying appendix E), being the strip along that coast, limited toward the interior by the water-shed of the Atlantic streams, already numbers its many millions.

The reports of the "Geographical Survey West of the One Hundredth Meridian" relate to 359,065 square miles, situate in fourteen of the fifteen political divisions lying west of that longitudinal line.

The actual area of survey from 1869 to 1879 (359,065 square miles) is distributed in the following proportions in the basins of drainage herewith: 1. Colorado, 130,200 square miles; 2. Interior, 106,500 square miles; 3. Rio Grande, 50,400 square miles; 4. Arkansas, 23,100 square miles; 5. Sacramento, 22,900 square miles; 6. Coast, 11,900 square miles; 7. Columbia, 11,300 square miles; 8. Missouri, 2,765 square miles.

At the commencement (1869) the only transcontinental railroad through this area was that of the Union and Central Pacific and their eastern connections; while to-day (January, 1887), the Southern Pacific meets the Atchison and Topeka, the latter branching to the Mexican coast at Guaymas, making a through route, with connections to San Francisco and San Diego

The Atlantic and Pacific has been constructed westward along the Colorado plateau beyond San Francisco Mountain to join a branch of the Southern Pacific at or near the Needles on the Colorado River, thus establishing within a brief period three distinct lines to the Pacific, independent of the Guaymas connection; while the more northerly line (outside of the survey area), the Northern Pacific, has been completed, and the Denver and Rio Grande narrow gauge has penetrated westward to Utah and southward toward old Mexico. North and south lines have been opened, notably from the Central Pacific Railroad at Ogden, Utah, Palisades, Battle Mountain, and Carson, Nev., and local roads reach to the centers of production in many directions; and thus gradually this land of mountain and desert, forest and waste, with arable stretches at irregular intervals, is being reached by rapid transit from thickly settled regions, and the products of the ranch and mine may now, from a constantly increasing number of points, be carried with ease to an ever-increasing circle of consumers.

The Atchison and Topeka Railroad also has connection at El Paso with the Mexican Central, already built to the city of Mexico, and other routes are projected to enter Mexico from Texas, and other rail communication with our southern neighbor has been successfully inaugurated.

CHAPTER I.

AREAS OCCUPIED.

The several expeditions, from 1869 to 1879, inclusive, were enabled to extend the observations required, upon which to base a detailed topographic map, to embrace an area of 359,065 square miles, distributed as follows, viz: New Mexico, 80,052 square miles (or 66 per cent. of its total area); California, 64,906 square miles (or 41 per cent. of its total area); Nevada, 62,181 square miles (or 60 per cent. of its total area); Arizona, 61,876 square miles (or 54 per cent. of its total area); Utah, 38,969 square miles (or 46 per cent. of its total area); Colorado, 33,041 square miles (or 32 per cent. of its total area); Idaho, 8,877 square miles (or 10 per cent. of its total area); Oregon, 8,842 square miles (or 9 per cent. of its total area); Wyoming, 231 square miles; and Texas, 150 square miles. In addition to these detailed topographic surveys, initial astronomic or geodetic points were established in Nebraska, Montana, and Washington Territory.

Topographic sheets have already been issued that delineate 326,891 square miles of the above area, while the sum of small areas (mostly remaining in plotting-sheet form) insufficient to publish as entire atlas sheets reaches 32,174 square miles.

A number of geologic maps, the initiative of a projected Geological Atlas, based upon the above topographic sheets, have been issued as material was gathered.

The annual reports comprise, besides the simple operations for the year, special descriptive and technical details.

The main quarto volumes (eight in number), devoted to special subjects (as astronomy, geology, &c.), are within themselves complete, as to the subjects embraced, at the date of issue, and there but remains the general Geographical Report from the main body of which all allied and technical material will be excluded.

EXPEDITION OF 1869.

The expedition of this year traversed an area of (approximately) 24,428 square miles, including 24,028 square miles in southeastern Nevada and 400 square miles in western Utah.

The basins explored and mapped were southern portions of the "Great Interior" and central parts of the Colorado, north and west of the great southern bend. The principal streams encountered other than the Colorado from south to north, are the "Virgin River" and Muddy Creek, a tributary heading in Pahranagat Valley, with a small affluent having its source at the head of Cedar Valley near the Utah boundary; also portions of the western part of the Sevier Lake Basin, the Humboldt, and a number of southern tributaries, independent of minor streams issuing from the mountain sides and sinking within the confines of the neighboring troughlike valleys, that are generally subordinate interior basins, integral parts of the elevated, mountain-inclosed area, without ocean outlet, known as the "Great Interior Basin."

NOTE.—The general route pursued by Lieutenant Wheeler in the expedition of 1869 was as follows: San Francisco, Cal., to Halleck Station, Nev., on the Central Pacific Railroad; thence to Camp Halleck, Nev.; thence to Elko, Nev.; thence to Old Fort Ruby, via Huntington Valley; thence to Hamilton, White Pine District, via Long Valley; thence to Cave Valley via Steptoe Valley; thence to Preuss Lake, (so-called), Utah, and return; thence to Panacca and Pioche via Cedar, Eagle, and Rose Valleys; thence to West Point via Grape Vine Cañon and Meadow Valley Wash; thence to Las Vegas via mouth of Virgin River, and northern bank of Colorado River to El Dorado Cañon; thence to Indian Spring via Spring Mountain Range; thence to Pahranagat District via Quartz and Summit Springs; thence to Monte Cristo Mill, White Pine District, via Quinn Cañon and Railroad Valley; thence to Camp Halleck via White Pine and Huntington Valleys; thence via Halleck Station to San Francisco.

The departure from the routes above stated, in this as for all other years, consisted principally in the detours necessary in the ascent of prominent mountain peaks, and in traversing the adjacent ranges, and in visiting important mining camps.

The measured mountain peaks above 10,000 feet approximately, are, Halleck, Humboldt Range, with four others unnamed; Grafton and White's Peaks, Schell Creek Range, and one other; Union, Snake Range, and one other, and Charleston, of the Spring Mountain Range, or eleven in all.

The trough-like detrital valleys between the nearly meridional ranges have sensibly the same trend, and with few exceptions are valuable only for grazing, on account of too great an elevation, poor soil, or want of water. The exceptions are Ruby, Steptoe, Duck Lake, and Pahranagat Valleys, with a number of smaller size near the borders of Utah, and where the Mormons had tilled the scanty-sized fields to good purpose.

The plateau system, so well marked in the area surrounding the Grand Cañon of the Colorado, and so widely developed in the central portion of the basin of this stream (named the "Colorado Plateau" by the writer in 1871), has but a slight representation in the 1869 area, consisting principally in a number of detrital mesas, adjacent to and on the northwesterly banks of this river, and along the most southerly area of the reconnaissance. The population of the area embraced was sparse and confined to the few cultivated valleys and occupied mining camps, and counted by a few thousand except for the temporary influx into the White Pine District, while so far as concerns topographic material, relating even to horizontal dimensions, the then existing map of this region was almost a positive blank.

The early Government explorers who had previously crossed this area in any direction, and whose reports have come under my notice, were Colonel Steptoe, along the northern portion in 1855; Captain Simpson, Corps of Topographical Engineers, to the southward and in nearly an east and west direction while en route from Salt Lake City, Utah, to Carson, Nev., in 1859; Captain Frémont, in 1844, while en route to California, along the lower route across the Great Basin first named by him; while in 1867 Major Sidney Lyon, formerly an Army officer, traversed southeasterly from Austin, Nev., to the Mormon settlements in southwest Utah. So far as can be ascertained, no one of these parties determined astronomical latitudes or longitudes, at points within the expeditionary area of 1869, except Captain Simpson.

The land surveys had advanced but little into this section, only approximately 3,500 square miles having been subdivided at the date of the expedition, since which time, however, marked advances in settlement are shown by the advance of the surveys and by the mining claims in numerous localities that have been entered and subdivided in accordance with the mining law of 1872.*

The Indian tribes noted, and of which the total number approximated 2,500 men, women, and children, were the Shoshones, Gosiutes, Snakes, Pah-vants, and Pah-Utes. None of these were on reservations, and roamed at pleasure, eking out a purposeless existence, principally by hunting, fishing, and from the store of piñon nuts found at infrequent intervals along the foot-hills and lesser mountain groups.

While the greater number of these Indians profess to be peaceful, yet massacres of small parties in isolated cañons were still of frequent occurrence.

It was impracticable, on account of the rapid nature of the reconnaissance, to collect data by which to classify the lands, although it may be said that grazing everywhere predominates, except for the many barren localities, while timber, mostly pine of the larger varieties, is found in the mountain ranges at the higher altitudes, the piñon being noticed along most of the rolling foot-hills in greater or less profusion.

A number of mining camps were visited, and areas, composed entirely of the earlier grades of volcanic rocks, or of the junction between them and the sedimentaries, indicated fields for careful and intelligent prospecting, much of the former of which has since been done, while for long periods these many ranges will hold hidden their mineral secrets, only to be revealed as time, forced on by American activity, shall come to the rescue, and one series of mining ventures after another follow in rapid succession, until this industry, as applied to the precious metals, shall become more systematic and fixed.

The water supply of the greater part of this area is extremely limited, the rainfall of the valley portions seldom exceeding 4 to 5 inches per annum, although that of the mountains, including the winter snows, is considerably greater. The Colorado River bounds the southern portion of the area that is along its immediate northern banks, a mountainous and valley

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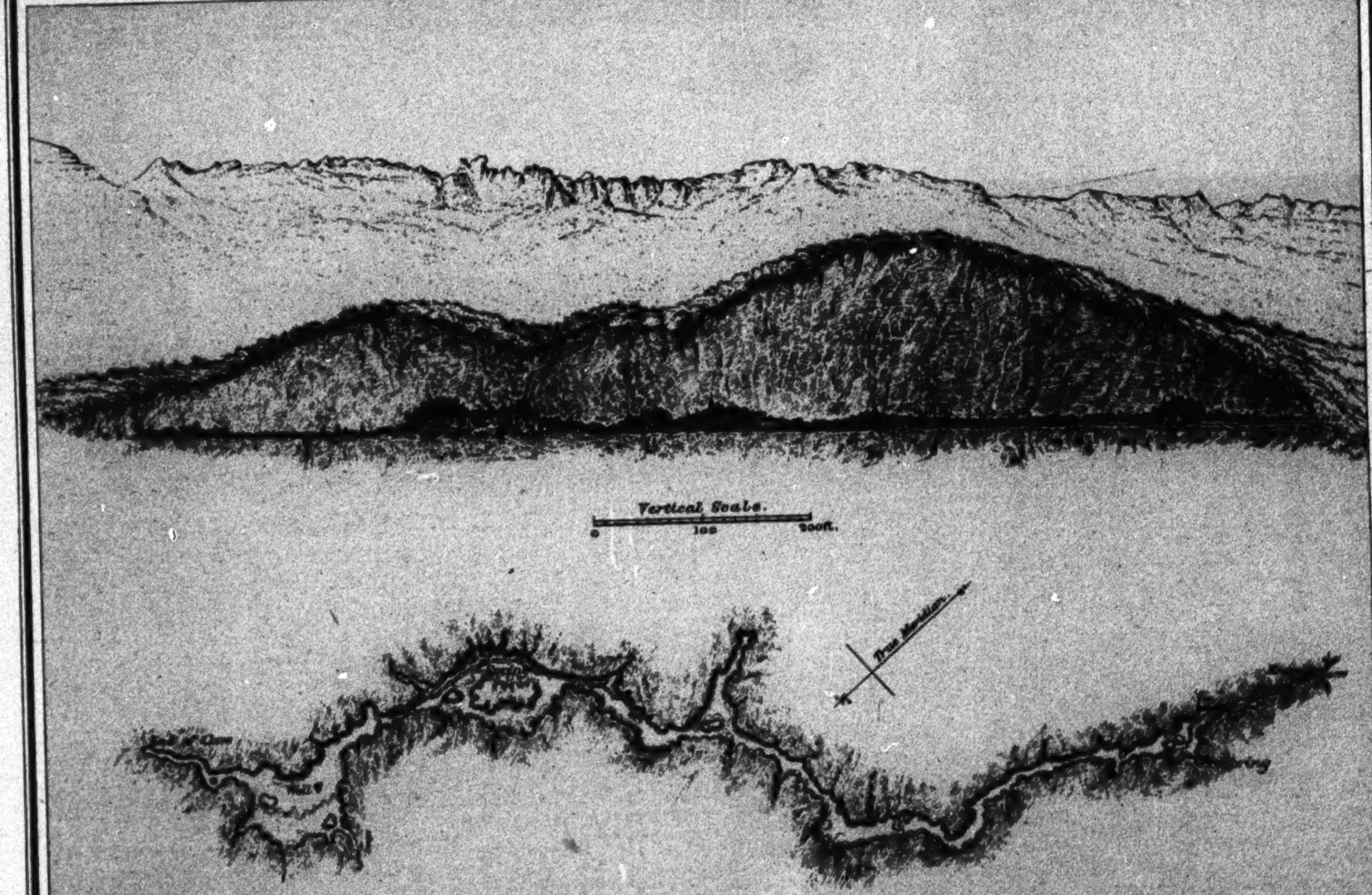
* Surveys by General Land Office had subdivided 32,793,702 acres, or 51,240 square miles, in Nevada up to June 30, 1888, out of an estimated area of 112,090 square miles for the whole State.

PLATE No. I.


Vertical Scale.
0
100
200ft.
True Meridian.
End of Cave
Wall
Spring

Plan and Section of Cave, in Cave Valley, Southeastern Nevada.

Horizontal Scale.
100ft
0
500
1000ft.

Surveyed by F. W. Hensel, 1869.

Drawn by Wyan W. Thompson.

The Graphic Co. N.Y.

desert, interspersed with mesas. The Humboldt, an inconsiderable stream of the Great Interior Basin, skirts the northern portion. A few lakes are noted in the valleys lying east of the Humboldt Range—the reservoir of Sevier River and in Pahranagat Valley. But comparatively little land can be restored by irrigation so far as could be determined from a cursory view. Artesian wells will doubtless some day prove of local service along the mountain flanks at selected localities.

The average mean temperature at the Signal-Service station at Pioche, Nev., toward the southern portion of the reconnaissance area, for the years 1878, 1879, 1880, 1881, and 1882, was found to be 49°.8 Fahr. The maximum monthly average was 74° for August, 1878, and the minimum 26°.4 for January, 1882.

The average precipitation for the same period was 6.71 inches per annum; the annual means varying between 8.36 inches and 4.67 inches.

The mean relative humidity for the above five years varies between 32.9 and 43.8.

The means of communicating along northerly and southerly lines are amply practicable. Such routes have been availed of for the small number of wagon roads needed in the condition of settlement of the country existing in 1869.

The position of east and west routes is practically determined by the mountain passes that exist in the several longitudinal ranges, and hence are more limited in number. Upon favorable developments in the mineral areas these valleys will be finally traversed by a system of narrow-gauge railways (north and south), with feeders or arms extending laterally, east and west, into the mountain cañons.

NOTE.—*Plate I* is here introduced showing the plan and section of a cave in the mountain limestone partially explored in Cave Valley lying due south of Steptoe Valley, that appears to underlie a number of small buttes westward from the main range, in which the same limestone appears heavily bedded. Its exploration was made by a party of 23 to a right-line distance of 3,000 feet from the orifice, developing walls of 700 to 800 feet in height, with dry chambers for nearly 2,000 feet of the distance, the balance approaching the sink at the furthest distance from the opening, showing the presence and action of percolating waters, reaching a pit apparently terminal for this level which it was found impracticable to explore for lateral connections, that may, for all that is known, extend in any direction.

North from Old Camp Ruby a distance of several miles a stream of considerable dimensions was found emerging from the flanks of the Humboldt Range, which could be followed for a distance within its limestone walls to an orifice nearly filled by the volume of the discharge. This volume was not less than 2,000 feet per second, hence its cutting power with the velocity of emergence was very great, and doubtless along its course in the interior of the mountain structure passages of no little size have been eroded, to appear at some later day in the drainage of this basin as cave amphitheaters and avenues.

Thermal springs were noted at the following points: Near Elko; also in Spring, Ruby, White Pine, and Pahranagat Valleys, at Panacca, in Meadow Valley, and in the wash to the southward. (See vol. 3, p. 150.)

The mountain ranges are generally anticlinals, with doubtless the corresponding synclinal, with a similar strike, below each adjacent detrital valley. Heavy limestone and quartzite beds are a marked feature, overlaid with rhyolitic or other eruptive masses, or as intruded beds, in many cases the sedimentary formations being entirely covered. The rapidity of the march gave no opportunity for either geological examination or collection of specimens. Parts of the area of 1869 were again entered in 1871 and 1872, when geologists and other collectors were added to the *personnel*.

The superficial evidences of vein phenomena were many in the several districts then located, and as a better understanding is had of the relationship of the volcanic beds that are mineral bearing and the accompanying country rock, there will be found, it is believed, much more to tempt the miner. This wilderness of ranges and mountain ridges found in the great interior basin and other portions of the west visited by the parties of the several expeditions impress one fully with the opportunities for persistent mining when the same is converted, as is now rapidly being done, from the position of a sporadic effort to that of a fixed industry. The number of north and south mineral belts so called can scarcely be estimated; on the thirty-ninth parallel it cannot be less than fifteen, according to present discoveries, and the ground is scarcely scratched.

Boundaries of the Great Interior Basin but imperfectly known along the southern and southeastern rim were traced and many sub-basins, the waters of which sink in the detritus or rocky strata of the plain-like valleys, were made known for the first time.

The interior plateau climate of this so thoroughly desiccated region at all elevations above 2,000 feet, during the summer months was found superb in the extreme. From August 10 to the evening of October 27 not a rain cloud had been noticed by night or day by the valley parties, and the brilliancy of the moon often made it possible to read by its light.

Partial lake terraces were noted in certain of the more prominent valleys, and it now seems evident from the lacustrine beaches, discovered in 1871 by the expedition of that year and by Clarence King along the fortieth parallel, that the larger share of the "Great Interior Basin" was not long since the bed of great lakes having outlets northwardly or southwardly to the ocean

These bodies of water have drained away, and residuals of a secular desiccation have dwindled to that condition of semi-desert now so well known, the small reservoirs of Great Salt, Sevier, Humboldt, Winnemucca, Carson, Walker, Owens, and a few minor lakes being the only water surfaces of the former expanse.

The artemesia of the plain-like valleys holds sway throughout the area, the bunch-grass clothes the foot-hills and the semi-mesas except for the more desert part of the area on the south and near the banks of the Colorado.

Certain of the valleys in the eastern part of Nevada are clothed with well-bedded grasses in the bottoms that afford a natural annual yield of both fair quantity and quality.

The mountain streams are stocked with trout. The varieties of fish and animals of all descriptions are extremely few, as also the individual specimens. The area is almost destitute of game except for such smaller varieties as duck, geese, crane, and sage-hens. A few blue-winged grouse are found in the higher elevations, and quail to the southward near the valleys, and deer have been noted in the Humboldt and other like prominent ranges. In the southern or desert-like portions of the area rattlesnakes and reptiles were abundant. No Indian ruins were seen, and, indeed, the student of antiquities will find but little to reward him in the region visited by the expedition of this year. It was determined that the hypothetical lake named "Preuss," after Frémont's chief topographer, and hitherto placed on the maps as being crossed by the boundary line between Nevada and Utah, was without doubt the alkaline flat (overflowed from Sevier Lake at seasons of high water) lying to the southward of this lake, and between the Hawawah and Beaver Creek Ranges. It determined also that several Mormon settlements, containing about 2,500 inhabitants and several thousand acres of tillable land, heretofore supposed to be in Utah, were actually in Nevada.

The minerals noted were mostly gold, silver, copper, lead, antimony, iron, salt, gypsum, alum, and cobalt (silver predominating), the well-known Meadow Valley mining district, with Pioche as a center, having been the largest producer.

The towns were few, sparsely settled, and uninteresting; the many short creeks from the mountain sides usually sink before reaching the central portions of the valley. The discharge of the Muddy (more a creek than a river) at West Point is not less than 5,000 inches, and of the peculiar springs near Las Vegas, 1,500 inches approximately. The Colorado River (traversed for 70 miles along its northern bank), with a drainage of 175,000 square miles, was afterwards gauged at Camp Mohave and Fort Yuma (see years 1875 and 1876), and circumstances of its navigation were ascertained during the river trips of 1871.

Of the twenty-three valleys traversed there was found not to exceed 250 square miles of arable land, of which 18,000 acres lie in Pahranagat Valley, all of which practically requires irrigation.

The mountain peaks vary between elevations of 8,500 to 13,000 feet; the vegetation reaching 11,500 feet where observed on the thirty-ninth parallel. The other elements regulating the superior altitude of vegetation being (1) grade of slope, (2) mean temperature, (3) relative humidity. The principal timber is of the pine, piñon, cedar, fir, spruce, and cottonwood varieties, and may be noticed, in sparsely distributed forests, along the Humboldt, Schell Creek, Snake, and other ranges; in the mountains south of

White Pine and east of Railroad Valley; southeast of Clover Valley and along the southern extension of Schell Creek Range at three points before reaching the headwaters of the Muddy. Covering the foot-hills piñon and stunted cedar abound. The bunch grass of the rolling foot-hills, so luxuriant and fine of fibre, is changed within the Colorado River Valley zone into a coarser variety known as "hard tack."

Wherever land is cleared of large sage brush and brought under cultivation by means of irrigation, the underlying vegetable mold, always dark, is found to furnish a most prolific soil.

In the portion of Southeast Nevada visited, the maximum temperature of points up to 7,000 feet altitude noted was 100° Fahrenheit; the minimum winter temperature reaching, as has been recorded, 15° below zero.

Mid-day temperatures in the shade, of 118° and 120°, were noted on the banks of the Colorado, but scarcely so oppressive as those of 95° to 100° Fahrenheit in the more humid climate of the eastern seaboard. A system of strictly scientific observations at selected points in the great interior basins and the plateaux of the Far West at elevations from 3,000 to 8,000 feet will develop, it is believed, equable conditions of climate, showing small *actual* and large *relative* humidities, and promising a salubrity that cannot be found in other portions of the United States, where the rainfall is so much in excess, and equal if not superior to the far-famed mesa sections of old Mexico; for the distinctive mesa and plateau forms only receive their full development upon reaching the latitudinal confines of the United States.

The rich, succulent bunch grass has been found most valuable for stock-raising, and the areas suitable have been already largely, if not entirely, utilized for this purpose. In 1869 cattle and sheep were being driven in from distant points, even as far as from Texas, but horses and mules were scarce. The soil is generally good for mountain roads, but they had been poorly made, with scarcely an exception, and were wanting in repairs.

The highest point in this area is the summit of the Snake Range (barometric height 12,063 feet). This peak had been named Jefferson Davis in 1854–'55 by Colonel Steptoe, after the Secession and Confederate leader of that name. Mr. White, State mineralogist of Nevada, at the date of its ascent for the first time by himself, myself, and party, suggested a change to that of my own, which idea was abandoned when it was learned that Captain Simpson in 1859-'60 had, from the valley below, passed this locality and suggested the appellation of "Union," which name has been adhered to in the office of Geographical Surveys. Although narrow-gauge railways have not yet (January, 1883) entered any portion of the 1869 area, yet elsewhere, in many sections traversed in the West, they have been introduced with economic effect, and the prediction of the writer in 1868 to the effect that for short meridional lines and local mountain routes this means of communication would prevail in the main, has been realized in scores of instances. Special maps of this reconnaissance were made on scales of 1 inch to 6 miles and 1 inch to 12 miles; the material, later on, being incorporated into the atlas on scale 1:506,880, and where necessary into sheets, scale of 1:253,440.

The material collected, supplemented by that of 1871, 1872, and other years, was finally incorporated and published in the regular topographic atlas sheets, Nos. 40, 48, 49, 58, 59, and 66.

EXPEDITION OF 1871.

This expedition traversed and examined an area of approximately 72,250 square miles, including 18,811 square miles in Eastern California, 29,600 in Northwestern and Central Arizona, 23,039 in Southern and Southwestern Nevada, and 800 square miles in Southern Utah, during an exceptionally long field season, commencing early in May and ending late in December.

The basins of drainage, entered, traversed, and mapped, were central portions of the "Great Interior," and of the Colorado of the West. The principal streams surveyed, forming sub-portions of the above basin areas, are the Humboldt with Maggie Creek and North Fork of its northern, with Smith and Humboldt Creeks of its southern, tributaries; again to the southward are the basins of the Virgin River and Muddy Creek, partly examined in 1869, and that entire of Owen's River, finding its reservoir in the lake of that name; the Mohave, also now known to be a member of the separated family of little interior depressions without sea outlets, making up the whole of the undrained basin of the great interior plateau. The tributaries of the Colorado to the southward, traversed and followed are: The Bill Williams Fork, also its confluents, the Big Sandy, Santa Maria, &c., Little Colorado and Diamond Creeks, and other creeks entering the Grand Cañon from its mouth to that of Diamond Creek; the basins entered still further to the south, as the San Carlos, Hassyampa, Agua Fria, Salt River, San Pedro, and Santa Cruz, are affluents of the Gila, while in turn certain of the prominent tributaries of the Salt River are the White Mountain creeks, Tonto, Pinal, Cañon, also creeks rising in the Colorado Plateau, the Tonto Basin, and the Sierra Blanca Range, many of which were visited and explored for the first time by white men.

In order to render clear, in this connection, the purposes of this expedition, a copy of departmental instructions is herewith:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 23, 1871.

SIR: The Secretary of War, in his orders of March 18, 1871, a copy of which has been furnished you, has assigned you to the charge of the exploration, under the direction of the Chief of Engineers, of those portions of the United States territory lying south of the Central Pacific Railroad, embracing parts of Eastern Nevada and Arizona.

The main object of this exploration will be to obtain correct topographical knowledge of the country traversed by your parties, and to prepare accurate maps of that section. In making this the main object, it is at the same time intended that you ascertain, as far as practicable, everything relating to the physical features of the country, the numbers, habits, and disposition of the Indians who may live in this section, the selection of such sites as may be of use for future military operations or occupation, and the facilities offered for making rail or common roads, to meet the wants of those who at some future period may occupy or traverse this portion of our territory.

In ascertaining the physical features, your attention is particularly called to the mineral resources that may be discovered, and, where the indications would seem to justify it, you should have minute and detailed examinations made of the locality and character of the deposits.

The influence of climate, the geological formations, character and kinds of vegetation, its probable value for agricultural and grazing purposes, relative proportions of woodland, water, and other qualities which affect its value for the settler, should be carefully observed.

The latitude and longitude of as many as possible of the important points should be accurately determined, and in order to assist you in this, it is suggested that you make arrangements with the officers in charge of the United States Lake Survey and United States Naval Observatory, so as to determine by telegraph the longitude of those points nearest to your field of labor, with which your field-work can be connected.

* * * * * * *

The following places are designated as convenient for depots, viz: Camp Independence, California; Camps Mohave, Hualapais, Whipple, and Apache, in Arizona; and Camps Wingate and Bayard in New Mexico.

You will use your own judgment in modifying the plan proposed in the event of any unforeseen circumstances or physical obstacles preventing an adherence to it.

To aid you in the discharge of these duties, Lieut. D. W. Lockwood, of the Corps of Engineers, has been ordered to report to you, and you are authorized to employ ten assistants as topographers, geologists, naturalists, &c., at salaries already authorized from this office in letters of previous date; also, the necessary number of packers, guides, and laborers to complete your party, the whole number of civilian employés not to exceed thirty in number. You will procure your assistants, employés, equipments, supplies, &c., at those points which seem to insure the most economical and effective organization for the party, and are authorized to pay their actual transportation to and from and to subsist them while in the field.

* * * * * * *

You will communicate with this office as often as the means of communication will allow, forwarding the usual reports and returns required by the regulations, and such other reports as will keep this office apprised of your movements, and the progress of the expedition under your charge.

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Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Lieut. GEORGE M. WHEELER,
Corps of Engineers, Washington, D. C.

Pursuant to these instructions the operations of the season were carried out with great vigor, and a preliminary report, accompanied by a skeleton map, scale 1 inch to 24 miles, was submitted and published shortly after return from the field.

The routes of early explorers traversing this area are those of: (1) Padre Escalante, 1776, en route from Santa Fe, N. Mex., to Great Salt Lake, Utah; (2) Frémont, in 1844, also 1845, in his southern route along the rim of the Great Basin, also from vicinity of Austin to eastern base of the Sierras, emerging via Owen's Lake; (3) Emory, 1846–'47, with the California column along the Gila River; (4) Captain Sitgreaves, in 1852, from the Zuñi villages, westward to the Colorado River, and thence along its banks to its mouth; (5) Lieutenant Whipple, 1853, along the 35th parallel route from Sunset Crossing to Los Angeles, Cal.; (6) Lieutenant Parke, along the 32d parallel, in vicinity of Tucson, to the east; (7) Colonel Steptoe, 1854–'55, from Salt Lake City into and along the valley of the Humboldt; (8) Captain Simpson, 1859, from Great Salt Lake, westward to Carson City; (9) Major Lyon (1867), from Austin, Nev., to Southwestern Utah.

The areas were joined with those occupied in 1869, and so on for the successive seasons the work was developed to cover contiguous sections of territory.

When the large latitudinal and longitudinal expanse, the extensive area, the long lines traversed, the broken mountain and desert tracts entered and for the first time made known as a whole, the multiple number of parties, their successful connection and co-operation, over a country where supplies had to be transported to advance depots, is considered, and when taken in connection with the successful ascent of the Colorado, the determination of its practical head of navigation, together with the fact that the regions south of the Colorado River, as well as a part of those to the

NOTE.—The route traversed by the officer in charge in 1871 was generally as follows: Washington, D. C., to Halleck Station, Nev.; Halleck Station to Camp Halleck and return; Halleck Station to Carlin; Carlin to Bull Run district and return; Carlin to Eureka, via Mineral Hill; Eureka to Morey district; Morey to Meadow Creek, near Belmont, via Tyboe district; thence to Hyko, Pahranagat Valley; thence via Oasis Valley to Camp Independence, Cal.; thence to Cottonwood Springs via Cottonwood Cañon, Death Valley, and Ash Meadows; thence to Camp Mohave via Ivanpab; thence to mouth of Diamond Creek via Colorado River and Grand Cañon; thence to Truxton Springs; thence via Mineral Park to Hualapais Springs and to Camp Hualapais; thence to Prescott; thence to San Francisco Mountains; thence via Rim of Plateau to Tonto Basin and Camp Apache; thence to Old Camp Grant, Ariz., and to Tucson, Ariz.; thence by stage to San Diego, by steamer to San Francisco, Cal., and by rail to Washington, D. C.

north of it, were infested by hostile Indians, making a perpetual guard a necessity by night and day, all of this, coupled with the unflinching courage, perseverance, and tenacity of the *personnel*, one and all, make it apparent that the exploration of 1871 was one of the most important and useful of those intrusted to my charge during eleven expeditionary years.

Indians to the number of several thousand were noted, belonging to the following tribes: Shoshones, Pah-Utes, Chemehuevis, and Utes of Nevada and California; the Seviches of Utah, and the Mohaves, Apache-Mohaves, Hualapais, Cosniños, the Tontos, Pinals, Coyoteros, Mescaleros, and Arivaipas of the Apaches in Arizona.

No census or enumeration claiming accuracy had been made in 1871. The greatest number of the White Mountain Indians (Coyotero Apaches) at Camp Apache that had ever drawn rations at one time did not exceed 1,200 men, women, and children. It had been estimated that the total number of Apache warriors would not exceed 1,500; however this may be, their hardiness, in conjunction with a perfect knowledge of their broken mountainous and mesa region, in which their homes were situated, made them an enemy greatly to be feared. They were then entirely nomadic, true mountain Indians, unaccustomed and hostile to the intrusion of the whites, and restless and unsafe whenever on a reservation. The roaming Indians lead a precarious existence, alternating between valley and plain, foot-hills and mountains north of the Colorado River, subsisting on pine nuts, seeds of all kinds, jack-rabbits, lizards, and a few small birds; while south of the Colorado they live more upon game and fish, cook the mescal and certain cactus plants, cultivate small fields, and have ponies. In the valley of the Colorado small Indian fields of corn, melons, and squashes were seen. From among the Utes and Pah-Utes found north and west of the Colorado River, it was possible to obtain friendly guides, many of whom proved most valuable in pointing out the little hidden springs and streams, especially in the Death Valley country, Southwestern Nevada, and Eastern California sections.

Indians were being fed by the military authorities at a number of posts in Arizona, notably at Camps Apache, Grant, Verde, and Whipple. The plan pursued at the former, that I had occasion to suggest while serving on staff of commanding general, Department of California, was to issue tickets to each sub-chief or head of a family, at a general gathering, when all would be anxious to show their authority and get the greatest number together, as a basis for furnishing rations, when in case next ration day any members were absent, no rations would be issued to the particular family or band, until the entire number were remustered and absentees accounted for. This prevented the young bucks from being absent on the war-path, while rations would still be drawn for them at the reservation or agency. It is understood that this plan has since been tried with very good effect, and might well be made general. Some of the worst, if not worst, Indians remaining in the United States were those encountered in the lonely marches, away often from either highways or trails, on this expedition, whereas it is believed that ten years have so far changed the face of matters that an escort is scarcely, if at all, needed in any part of Arizona, unless during an outbreak, one of those periodical occurrences destined to come without warning, while the Indian race (fast giving way before white emigration) retain any of their native spirit. One cannot approach the subject of the Indian without reverting to the Stage massacre (see Prel. Rept., 1871, p. 29) near Wickenburg, Arizona (where three members of the expedition were murdered), long since proven to have been committed by Indians professedly friendly, and being fed at the expense of the Government. Maimum, one of the Mohaves of the river trip, who had formed a great fondness for the ill-fated Loring, was largely instrumental in ferreting out these red-skinned assassins, and some of their number were finally found and punished during General Crook's first command of the Military Department of Arizona. This is one of the evidences of the mistaken zeal, of the then peace-at-any-cost policy, that was for so long a time applied to the settlement of the Indian problem. Unfortunately, the bones of murdered citizens cannot rise to cry out and attest the atrocious murders of the far-spreading and wide-extending border lands of the Great West, and while the fate of the Indian is sealed, the interval during which their extermination as a race is to be consummated will doubtless be marked in addition to Indian outbreaks, with still many more murderous ambuscades and massacres. (1879.)

The rapidity of movement and plans of the expedition, depending upon reaching supply points at stated times, and long marches between waters, did not permit of taking careful notes in the topographic record of the various natural divisions, &c., of the soil, nor of its cultivation, as was commenced in 1872, and developed in later years to an actual economic classification, reduced to percentages and shown graphically by colors on the topographic map. Suffice it to say that much of the country traversed, such as Death Valley, Armargosa Desert, and portions of the Mohave and Colorado Deserts, are as unpromising sections as the sun shines upon, even were it the depths of the "Sahara;" while fringed with smaller desert areas, containing oases of appreciable extent, the ones above mentioned are almost destitute of vegetation and water. Valleys near the railroad, like the Reese River, are marked by narrow lines of cultivable ground, and much grazing is met with, especially in the foot-hills, and occasional patches of timber in the higher ranges, reaching tracts of considerable size. Much of the region belongs to the "Interior Basin," and to that portion of the "Great American Desert" found in Southwestern Nevada and Eastern California.

Shortly after crossing the Colorado the scene changes, and the rolling, broken mesas of the Colorado plateau are reached, where in many cases large areas of luxurious grass abound, with timber of the fir and pine species, one almost unbroken forest, except for intervening valley and glade, extending from far to the north and west of San Francisco Mountains to the eastward limit of the trip, the White Mountain Range, east of Camp Apache, a distance of approximately 350 miles, and varying in width from 60 to 100 miles.

Within this large area lies the "Black (juniper) Forest" of Ives, and its extent is only limited by the heads of the Gila River, and the ranges extending thence eastward, one by one, to the valley of the Rio Grande. This forest is without doubt the largest, single, connected timber expanse found south of the fortieth parallel and west of the one hundredth meridian. Its elevation is from 7,000 to 11,000 feet, in most localities below 8,000. The little glade-like valleys might, with much success, be turned to purposes of agriculture and grazing. In 1871 but little of the arable or grazing land had come into the market even in Nevada, since which date it is understood that subdividing surveys have covered the greater part of this section; and when one considers the comparatively few acres out of every hundred (not exceeding ten) that can be utilized by the farmer or stock grower, in connection with the Western tide of emigration, it is not difficult to see that before many decades every useful acre will be appropriated, in pursuance of the present land laws, when there will still remain in the hands of the General Government sterile wastes, not alone of millions, but tens of millions of acres, which, valueless for agriculture, stock raising, or mining, must for a long time remain unoccupied, even with the most liberal land-settlement laws. The cultivable area may be increased slightly through surface and artesian-well irrigation in the southwest, and by reprecipitation in adding slightly to the normal amounts of rainfall, from the interposition of larger areas of evaporation, and through other causes. The entire cultivable ground in Southern and Eastern Nevada is limited to small isolated spots, or narrow lines, while certain valleys in Arizona respond more liberally, notably the Chino, Williamson's, and of the Verde, in the north; along Salt River, in vicinity of Phœnix, and of the Gila, near Florence, and in vicinity of Pueblo Viejo at the south.

The Territory of Arizona, so long judged by the lines of transit through it along the lower Gila and other desert sections toward its southern border, bears a better character for productiveness of soil as its northern, central, and eastern parts become opened up and known. Not less than 10,000 acres were cultivated at Phœnix in 1871. The artemisia, or desert sage, disappears as the higher semi-plateau regions of Arizona are reached, and is replaced by rich bunch and grama grasses and shrubs, although the presence of a strong growth of artemisia is everywhere indicative of a fine undersoil, but usually valueless from absence of water. Except for portions of the Colorado Plateau and certain valleys in Arizona, the average percentage of arable and grazing land of the 1871 area was less than that for any single year, the arid area being largely in excess, which is not strange when one considers that the worst deserts of the West, *i. e.*, Death Valley, Amargosa, Mohave, and part of the Colorado, utterly destitute of vegetation except in rare spots, contribute to the area.

The mesas and valleys of the plateau systems and of parts of the Great Interior Basin have become the home of thousands upon thousands of cattle, to be limited only by the number of acres actually valuable for this purpose. The areas best adapted for grazing were all the open parts of the Colorado Plateau, of the Tonto Basin, and portions of the Upper Verde and Salt River, in Arizona. There is good grazing also in the Pahranagat and Muddy Valleys and portions of the Virgin River, near Saint George, Utah. The valley of the Upper Owhyee is exceedingly valuable for stock-raising, but of little use for agriculture. Stock ranches, generally small, were noticed in many of these valleys, and commencing with the advent of the Central Pacific in 1868 the valleys and adjacent mountain sides of Central Nevada commenced to be appropriated for this purpose. Fine grazing was also noted in the Hualapais and Sacramento Valleys of Northwestern Arizona, but scantily supplied with water. Good grazing also appears in parts of the valley of the Santa Maria and Big Sandy, both tributaries of Bill Williams Fork. To sketch the different kinds of lands would be to prolong this report far beyond a reasonable length.

Along the edge of the San Francisco Plateau, after turning eastward in going south from San Francisco Mountains, and toward Camp Apache, the Tonto Basin, with limiting ranges to the south, stands out full in view, an amphitheater of fully 250 miles east and west, and in width from 75 to 125 miles; showing, too, among its subordinate ranges large tracts of timber and many handsome grazing fields. The soil of the plateau is from old volcanic rocks of the dark variety of trachytes, deep, dark, and rich in most localities.

Forests of greater or lesser extent fringe the high mountains and plateau in Nevada and Arizona. Pines are found reaching almost to the summit of the Humboldt Range, near Camp Halleck, and southward towards Hastings Pass. Here mountain mahogany (*Cercocarpus ledifolius*) reaches nearly the altitude of spruces and poplars, and cottonwoods 1 to 2 feet in diameter mark the streams of the several gulches. No trees were noticed in or near Maggie Creek and Independence Valleys. Mountain mahogany was observed in many localities along mountain sides in Central Nevada. The summit of the Toquima Range enjoys patches of pines, while juniper and piñon (*Pinus edulis*) are noticed at lower levels, as is the case for most of the ranges in Central and Southern Nevada. The mountains northwest from and near Saint George, Utah, have considerable pine growth, and a dense growth of cedar is found at the head of the Grand Wash. Pine and scrub oak are noted about Bill Williams Mountain. The "Black Forest" of Ives is an area of densely-growing juniper, with pines and firs at the higher levels, and east of Camp Apache a heavy wilderness of pine (*Pinus ponderosa*, *Pseudotsuga Douglasii*, *Abies concolor* and *brachyptera*), interspersed with scrub oak (*Quercus undulata*), black walnut, and fir, appears. Heavy forests cover large portions of the Natanes Mesa and Pinal Mountains. Cottonwoods are noticed on most of the streams below the level of about 3,500 feet.

Juniper and piñon alone are found along that part of Reveille Range facing Hot Creek Valley. Fir and pine in patches appear on the slopes of the Timpahute Range, but only dwarf oaks at the foot. No timber of any sort was noticed from this range westward via Oasis and Death Valley to the Inyo Range; east of Owen's River Valley (distance approximately 150 miles) juniper and piñon clothe many of the divides of the ranges in Southwestern Nevada and Eastern California. On the San Francisco Plateau spruce and fir may be found in patches above 8,500 feet in altitude. The great forest of the Colorado Plateau extends southeastwardly for a distance of 400 miles, ending only near the Rio Grande, its width being variable and fully 100 miles at the greatest extension. It is estimated that the valleys and glades interspersed through it will reach 15 to 20 per cent. of the area, where below 7,500 feet the land can be cultivated with safety at and below latitude 33 degrees, and all of it is valuable for grazing. The soil is a dark, deep, rich loam from the older lavas, and will some day respond to the call of the farmer, especially when the pines of the lower levels are cleared. This is a noble forest, both in extent and size of trees, that grow tall and vigorous, the forest area being joined substantially to that of the Tonto Basin. Up to this date, ninety-two mining districts had been discovered within the field of the expedition, many of which were being worked on a lesser or larger scale, Pioche being the most productive of all. These were all located upon the map, most of them for the first time. Attention was invited as to their locality, to mountain environment, the character of ore, matrix and country rock, with reference to the methods of reduction in vogue. The areas within which it would be unavailable to search for the precious metals have in many cases been pointed out, both mineralogically and as regards geological exposures, and in certain instances, where the character of the country rock and its surroundings seemed to justify it, favorable localities for prospecting were suggested.

This year increased the available evidence showing that, with the exception of the older trachytes, the lavas more ancient than the basalt are, in most if not in all cases, certain indexes of the favorable localities for silver deposition, and more careful and intelligent prospecting should be rewarded by uncovering ore concentrations of economic value in hundreds, if not thousands, more districts within the many mountain ranges. Also, as a rule, no croppings of the precious minerals have been noted along the southwestern portion of the Colorado Plateau, visited in 1871; but the Great Tonto Basin has responded to the hardy prospector, with returns from its hidden wealth, in a number of points, not known in 1871.

The railroad lines constructed within this area since 1871 (at which date it was necessary to use the Central Pacific as a base) are: (1) the Palisade and Eureka; (2) the Battle Mountain and Austin; (3) the Atlantic and Pacific; and (4) the Southern Pacific touching the 1871 area in its more southern route from Florence to Tucson.

A railroad from Carson City to the southeast, thence to follow southward, and to the east of the Sierra Nevada, has also been constructed as far as Owen's Lake.

As mines develop, advantage should be taken of the meridional valleys, with low passes to the north and south, through which to carry lines belonging to the north and south systems, needed for the proper development of the country.

The only lakes known to exist in the entire area of more than 72,000 square miles are Fish Lake, Nevada, and Owen's Lake, California.

The Alpine Lakelet view (*Plate II*, a lithograph photographically based and representing a mountain water gem) is typical of the mountain reservoirs so frequently found, more particularly in the glacially carved ravines of the eastern flanks of the

PLATE II.

ALPINE LAKE IN THE SIERRA NEVADA, NEAR CAMP INDEPENDENCE, CALA.

1871

KEARSARGE MINING WORKS, KEARSARGE DISTRICT, EASTERN FLANK OF THE SIERRA NEVADA.
(NEAR CAMP INDEPENDENCE, CALA.)
1871

Sierra Nevada, and marks also the storehouse of moisture which, emanating from the perennial snow fields higher in the mountains, finds its source as well as the rugged nature of its surroundings nearly at the level of where perpetual snow begins.

The peculiarity of the Plateau drainage, the aqueous cutting having been largely through homogeneous beds, has not been favorable to lake formation, although the rain and snow fall would amply supply very large natural reservoirs, while north of the Colorado, and until the rim of the Great Interior Basin is reached, the Cretaceous sea might not so long ago, geologically speaking, have extended, and again to the northward the present condition of desiccation, inherent to this large expanse of desert, does not now admit of the storage of water in these natural trough-like reservoirs, they having for the most part become detrital valleys, while evidences of old lacustrine beaches are noted in Owen's River and other valleys to the northward, similar to the Lake Bonneville, the western edges of which were discovered in 1869 and further developed in 1872, so have other ancient lake beaches within the Great Interior Basin been discovered and their perimeter and relative elevations determined.

Outside of the streams noted, the water from any source was precarious and little in the extreme for the entire area north of the Colorado River and to the south as far as the rim of the Colorado Plateau, where, although the rain and snow fall becomes considerable, the number of permanent springs is still small, partly it is believed on account of the high percolating power of the underlying rocks.

Plate III represents the surroundings of a typical mining enterprise, the Kearsarge, being the principal property high up among the eastern flanks of the Sierras, in proximity to and westward from Camp Independence, Cal., with which it is connected by wagon-road, terminating at the mines, far distant from railroad transportation, and where a turbine wheel of 13¼ inches in diameter, driven by a small stream diverted from its mountain course, and given a fall of 156 feet, accumulates the force required to operate a twenty-stamp quartz mill, and proves a most valuable substitute for steam power.

The buildings, made of rough sawed pine, and the tramway to the mouth of the mine, appear in the foreground and center of the illustration. The rude, simple, at the same time wild and rugged exterior of these pioneer camps can readily be understood from the plate, which has been engraved from a photograph taken on the ground.

The district contains fissure veins of silver-bearing ores, mostly carbonates.

A cave eroded by water from mountain limestone was visited near Mineral Hill, similar to one in Cave Valley, Nevada (1869), although of less extent. The orifice leads into a large chamber fully 60 feet in width by 70 feet in length, and from 40 to 50 feet in height. This chamber leads along the main channel about 150 feet, then apparently closing, the sides being covered with brilliant crystallizations.

The northern half of the 1871 area lies wholly within the Great Interior Basin, and the observations serve to fix its southern rim, hitherto but illy defined, from the point at which it cuts the Utah boundary westward to the Sierra Nevada.

The degree of desiccation reached in this portion of the Great American Desert, especially in Death and Termination Valleys, the Amargosa Desert, and the sink of the Mohave, is a maximum; and extending northward through Ralston and a number of other valleys in Southwestern Nevada, and to the southward in the valley of the Colorado, the arms of the desert elongate, making one continuous chain of desert surroundings from the Mexican border as far north as the plains of the Columbia River in Oregon. There are oases, indeed, within this long and wide expanse, and vegetation appears even where all signs of humidity are absent, but the secular change being now one of desiccation apparently holds sway over all. While the wet and dry of the cycles of maximum and minimum rainfall are not yet determined the averages of a given number of years afford but an inadequate, if not incorrect, idea of the climatic oscillations in progress.

No coal croppings were reported during the entire trip except slaty beds, comparatively unopened, near Carlin, Nev. The area reconnoitered geologically was from 700 to 800 miles north and south and 100 to 250 miles east and west, the full report of which contains much detail concerning structure. The observations were facilitated by the absence of trees and soil, and large experience was had by the geologists in the broad field of generalization on account of the extended region under view. Volcanic beds are strewn with a liberal hand over the country to the southwest of Timpahute Range, in Oasis Valley, Amargosa Desert and Death Valley regions, while south of Termination Valley a large expanse of impassable basaltic beds (quite recent) lift their frowning, impenetrable, and almost jet-black heads. The granite ridge, forming the backbone of Telescope Range and falling away to the northward, joins the extensive volcanic beds lying eastward of the line of summits, which face directly on Death Valley, presenting rough, ribbanded walls (made up of different-colored lava flows), to the westward falling in gentle outline to the valleys through an eroded opening, of which, at the eastern end of a grand granite amphitheatre, a stream breaks as if by magic from the ground and keeps above the surface, being one of the few water-courses in the Death Valley region, and known heretofore, as were so many similar cases, only to Indians. The eastern slope of the Telescope Range makes an exceedingly abrupt descent of fully 10,000 feet into Death Valley, the area due east from Telescope Peak being below sea-level. The view of this escarpment from the heart of Death Valley is among the most picturesque of mountain scenes, and only equaled by portions of the long, continuous, seemingly perpendicular walls of portions of the Sierra Nevada facing Owen's River Valley. The geological and mineral collections, and others in the several natural history branches (in zoology, botany, fossils, &c.), went to swell the large and varied collections turned over to the Smithsonian Institution during a period of ten years, no detailed record of the contributions having been kept at the Office of the Survey until subsequent to 1876.

The remnants of ruins of a former race were noticed at many new places in Arizona, nothing special having been observed north of the Colorado. There is a wide field of search in the basins of the tributaries of the Gila, Salt, and Verde Rivers and of southern portions of the Colorado itself, some points of which have been touched upon in later expeditions, and much of which remains as unexplored ground. Of the latter the valley of Cañon Creek, reaching Salt River within the Tonto Basin, as well as other streams having their sources along the southern rim of the Colorado Plateau, are still, so far as known, both unprospected and unopened.

The portion of the Interior Basin, to which the name of Great American Desert has been applied, was entered along its widest expanse, traversed along a number of lines, its little oases made known, its general mountain, valley, and drainage configuration established, with such details as were possible to obtain in a *terra incognita* of so great extent, so difficult of access, and with no single route for hundreds of miles in any direction hitherto being known. The most striking change was noticed in the transit from the low desert-like valleys of Southwestern Nevada, Utah, and Eastern California to the high, rolling plateau of Northern and Eastern Arizona, where the succession of high serrated ridges, so common to the northern area, disappear, being replaced by sedimentary strata, covered by large lava flows, and forming a region well grassed and wooded, of good climate, and highly picturesque scenery. The southwestern portion of the Great Interior Basin, a considerable portion of which was demarked for the first time, is made up of a number of local inclosed interior basins, like the Owen's River, Death Valley, and Amargosa, either of them terminating in an alkaline flat or a reservoir like Owen's Lake.

Pretty conclusive evidence was obtained connecting the basins of Death Valley and Amargosa with that of the Mohave, as a part of the same land-locked area, although the line of junction was not actually followed from the depression between the two former with the reservoir sink of the latter.

The valleys of Southwestern Nevada and Eastern California are, with scarcely an exception, sandy desert wastes, generally accompanied by the typical alkaline flat and mountain-locked. The ranges are, in the main, of sedimentary formation, resting on granite, with, usually, numbers of geologic horizons exposed, through which volcanic beds of varying forms and ages have been interjected, constituting a series of wave-like anticlinals or reversed synclinals, along the latitude of 38° north from the Sierra Nevada to the Wahsatch, a veritable ocean of mountains. As before stated, only isolated farming spots occur, considerable grazing, more usually in the foot hills, a scanty supply of timber, with great mineral possibilities, but with an infrequent and inconstant supply of water is found almost everywhere. The expedition gave a clear insight into the Grand Cañon system and served to determine a part of the perimeter of the Great Colorado Plateau, first recognized by the writer in 1868. As a type of the

"Box Cañon" regions of Arizona, the country drained by the Santa Maria from the Aquarius Range to the Juniper Mountains, is the most intricate, interesting, and difficult. This was traversed in a northeasterly direction by myself and southerly by Lieutenant Lyle, and embraces about 12,000 square miles.

The eroded walls of lime and sandstone are basalt-capped, presenting every variety of contour, black, ugly, and frowning, with escarpments impossible of ascent or descent, except in friendly openings where the drainage of minor side ravines had cut out more gentle slopes. This region was the stronghold of the Apache-Mohaves, where they had hunted and fished for unnumbered generations, and more lately murdered to their hearts' content.

The area embraced by this expedition falls within and will be found delineated upon the following Atlas Sheets, sixteen in number, viz: 39, 40, 48, 49, 57, 58, 59, 65, 66, 67, 73, 74, 75, 76, 83, and 89.

A reference to this expedition may be found as Appendix DD, A. R. C. of E., 1872; also A. R. C. of E., 1871, p. 103.

NOTE.—As a specimen of the hardships of the campaign, the march from the northwest arm of Death Valley via Termination Valley to the Inyo Range may be cited.

The route lay for more than 39 miles in light, white, drifting sand, which was traversed between 5 a. m. and 6 p. m., the center of the desert being reached about meridian. The stifling heat, great radiation, and constant glare from the sand were almost overpowering, and two of the command succumbed near nightfall, rendering it necessary to pack one man on the back of a mule to the first divide on the route, where a grass sward was reached at the end of the long, sandy stretch, while the second, an old and tried mountaineer, became unconscious for more than an hour in nearly the same locality. This happened, fortunately, near 6 p. m., when the sandy waste was mostly behind us. With water from the canteens these men were restored to consciousness, and the march resumed by moonlight, without trail or guide. A living stream was reached between 3 and 4 a. m. at the eastern base of the Inyo Range, after a continuous march of over twenty-three hours. Other marches of this trip, but not in quite such desert sections, have extended from fifty to sixty and even eighty hours, with scarcely a single halt.

EXPEDITION OF 1872.

The survey received the specific sanction of Congress by act approved June 10, 1872, made in pursuance of a project laid before the Committees on Appropriation of the House of Representatives and Senate for the detailed topographic survey of the entire territory of the United States west of the one hundredth meridian.[*]

The area embraced by this season's work approximates 47,366 square miles (Arizona, 11,766; Nevada, 5,384; and Utah, 30,252 square miles). It lies for the larger part within the Great Interior Basin, the balance belonging to the central portion of that of the Colorado of the West.[*]

The principal cañons within the area are the Grand, Marble, and Iceberg, of the Colorado of the West, the Kanab and Paria, of its northern tributaries, the Provo, &c.

Partial itinerary or rough notes of trip from Provo River and Valley to Strawberry Valley, thence via Spanish Fork and Thistle Creeks to Sam Pitch Valley, thence eastward along edges of Castle Valley and return, thence reaching Little Salt Lake Valley, via head of Sevier, to head of Virgin River (*See Atlas Sheets* 50, 59, *and* 67.)

August 10, 1872.—Left camp at Provo, ascending the banks of the river of that name, entering the cañon, which has cleft its way through the entire Wahsatch Chain at this point. A wagon road for transportation of coal and other supplies from valleys beyond to Utah Valley leads through this cañon to Provo Valley.

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[*] This project has never been in print, but was a plan substantially for a complete connected continuous detailed topographic survey (with associated natural history observations) of the territory of the United States west of the one hundredth meridian, with primarily a resultant topographic map scale 1 inch to 8 miles, to be in the main an aid to military administration and operations, to occupy about 15 years, and to cost, in all, not exceeding $2,500,000.

Independent of all other information given in the various publications of the survey, a reference to its extent, methods, cost, and cost of completion will be found as Inclosure No. 3 to Sen. Ex. Doc. No. 21, Forty-fifth Congress, third session. It was to have been the first great general survey of the country during its initial stages of settlement.

[*] NOTE.—The following is the general line of the routes followed by the officer in command during the field season of 1872, departed from in the various mountain camping and climbing detours necessary for detailed observations and the practical execution of the work: From camp near Salt Lake City to mining districts about Parley's Park and return; to Little Cottonwood Cañon and return, via heads of American Fork and Big Cottonwood Cañon; thence to Provo, Utah; thence to Spanish Fork via Provo Valley and Cañon and Strawberry Valley; thence to Thistle Valley via Spanish Fork; thence to Utah Lake Valley and circuit to Sam Pitch Valley via Nephi; thence to the eastward across the range and along flanks of Castle Valley and returning to Sam Pitch Valley (without trail); thence to Nephi via Gunnison; thence to Fillmore; thence to Beaver and Panquitch via Parowan; thence via Sevier Plateau and head of Virgin River Valley and Cañon to Toquerville; thence to Saint George; (all in Utah) thence to mouth of Grand Wash, and via Stone's Ferry to Hualapais District and Mountains (Arizona); thence returning northward via Meadow Valley to Pioche, and thence to the Central Pacific Railroad at Palisades, Nevada.

A beautiful twin, or double cascade, with a fall of more than 100 feet, breaking from the south face of the cañon walls, immediately south of the ford, is formed by a little mountain stream, heading in a lateral cañon.

Tired, wet, and hungry, camp is made (about 9.30 p. m.) near and opposite the mouth of the South Fork of the Provo River. Fresh discoveries of argentiferous galena (similar to the beds in American Fork Cañon) were reported on the North Fork of the Provo River, not far from its confluence. A quarry of variegated marble is found on Snake Creek, near the Hot Springs visited in eastern portion of Provo Valley. A spring from which sulphur fumes escape continuously was passed (temp. 72° F.).

The principal spring of the Provo Valley Group, of which the crater-like mound is the highest (67 feet above base), bubbles up a miniature volcano with a temperature of 108° F. Several clusters are visited within a radius of 1,000 yards, with temperatures as low as 88° F., and with colors of bluish, greenish, and bluish-black tints. Many scattered over quite a space in this wide, open valley were noticed as extinct. This group can aptly be called the "Volcano" springs.

The eastern flanks of the Wahsatch, facing toward Provo Valley, show denuded faces with much clearness, the beds making up the Wahsatch Chain, in the shaded valleys of which, near the summit, permanent snow is found.

August 13, 1872.—The route from Provo to Strawberry Valley follows Daniel's Creek to its source, and thence by a gentle summit or pass to the head of Strawberry Creek, along a natural wagon-road. The "sarviche" berries, so much sought after by the Indians, appear abundant and in full fruit. The beavers, rarely seen by day, still hold possession of the part of the stream in the vicinity of the valley, their dams recurring at short intervals. This was a favorite trapping ground in the days of the early explorers.

Short-leaved pines and mountain firs are met with, not large in diameter, but of extreme height. The groves of quaking aspens increase in size from the edges of either valley to this summit, which marks the divide of the waters between the Great Salt Lake and Colorado Basins, and mountain slopes stretching in many directions are lined with aspen groves as far as the eye may reach.

Furniture is sometimes made of the larger specimens; otherwise it is of little use beyond its value for fencing and fuel. Strawberry Valley forms a part of the Uintah Indian Reservation, but it was not in 1872 utilized to any considerable extent by the Indians, and showed an expanse of elegant grazing ground, but probably at too high an elevation for crops at this latitude (altitude, 7,716 feet). It was followed along its western edge for nearly its entire length, whence it was the intention to pass westward into the north fork of Spanish Creek. A fortunate encounter with Indians (White Eye's band of the White River Utes) put us in possession of an old worn trail, along which, before reaching the summit, a camp was made in the edge of heavy timber. This band numbered seven lodges, with plenty of horses and a few goats, counting 11 bucks, 7 squaws, and 18 children (36 in all). They were on a hunting and fishing trip, and their outfit when mounted formed a unique miniature caravan. They were alarmed at the presence of even a few blue jackets, being absent from their proper reservation. They made the usual begging and palavering Indian visit to our camp-fire just at night fall.

A sulphur spring on banks of north fork of Spanish Fork Cañon (temp. 111° F.) was noted.

August 14, 15, *and* 16, 1872.—A partial rendezvous was made on Soldiers' Fork of Spanish Creek, and the march continued to Sam Pitch Valley and camp made near a settlement called Wales.

A visit was made to opened coal-beds in Coal Cañon, among the foot-hills west of Wales. These mines are situated about 1¼ miles from the Cañon, through which flows a tiny creek, making the situation accessible and convenient for mining operations. One of the prospected layers (2 or 3 feet thick) pitches at the point of opening to the southward and dips toward the hill at an angle of about 50°.

The beds occur between layers of sedimentary limestone, with a persistent narrow limestone dike, thickness 9 or 10 inches and highly fossiliferous, traversing laterally the entire bed.

Immediately below the bed of limestone a deposit of fine quality fire clay, that has been successfully utilized, occurs. Lignite shows at the start and a bituminous coal (said to be coking) is shortly found. Sandstone, in contact with heavy vertical beds of conglomerate, occur at the valley mouth of the cañon.

August 25, 1872.—A detour to the eastward of the Sevier Valley was planned and a crossing made from near the source of Thistle Creek, about 1½ miles from which a summit is reached that either forms the immediate head or in close proximity thereto of six streams, viz: Thistle Creek, Soldiers' Fork, Strawberry Creek, White River, San Rafael, and Sam Pitch Creeks. The tortuous line of these several water divides was followed in a southeasterly direction until a trail, evidently leading in the direction of Castle Valley, was met and followed.

An exploration was made of the drainage approaches to Castle Valley, and as soon as rations ran low steps were retraced westward to reach Sam Pitch Valley, near Fairview.

This trip was made without trail or guide (the Mormon guide having failed us) and in hourly expectation of meeting with some of the predatory Utes.

Coal croppings were also visited in a cañon about 7 miles east of Fairview. Found a small opening in narrow limestone strata between layers on either side of sandstone, in which a narrow seam of lignite was developed in a drift of 18 feet, with poor results.

Scratchings had been made in four different cañons, and one is reported as showing cannel coal with 90 to 96 per cent. of carbon. Coal is reported in large quantities in the bluffs facing Castle Valley, at the head of White River, and seams were noted in a number of localities in this section.

Visited a large marine fossil-bed and a vein of bituminous shale—width of the latter 11 inches, with upturned edges. Chips could be ignited with a match, and it is said to distil and make paraffine and oil. Extensive chalk beds were also noticed in this vicinity. A cañon farther to the north was visited from Fairview, where a coal vein had been developed of thickness from 12 to 24 inches. There is a great future for the coal fields of Central Utah.

The waters of the Sevier could be utilized on a considerable scale for irrigation. It is believed that artesian wells could be sunk successfully on the eastern side of the valley about Parowan. Little Salt Lake, that appeared in the days of Frémont as quite a sheet of water, has since entirely evaporated, leaving alone alkaline flats.

In noticing the agriculture of portions of the region traversed, it was found that the Mormons were the only people who pursued that branch of industry with regularity, and invariably by the aid of irrigation. In some sections, as Pahranagat Valley, Nevada, and the location of the Moqui and Zuñi Pueblo Indians, in Arizona and New Mexico, by deep planting, crops are raised without resort to irrigation; but it is certain that such exceptional success attends only special localities, and is confined to special crops, particularly corn and melons. Alum beds are found in the cañons to the east of Parowan.

Indications of coal have been discovered in the center fork of Centre Creek, and a road is under construction to reach the timber that was being sawed for the Pioche market, a distance of 110 miles. Poplars, thorn, and maple occur along the cañon 15 miles out from Parowan.

Float copper and silver ore has been noticed in the cañon east of Paragoonah. Impure black obsidian beds had been prospected east of Beaver and taken for coal. Coal and cheap silver ore were found near the iron mines to the south.

Lignite was found near source of creek leading to the Colob plateau in exposed strata of heavy reddish limestone, with irregular, conglomerate, and volcanic beds in vicinity. Considerable heavy timber noted on this plateau, which joins the Parowan Range. A steam saw-mill was in process of erection, with over 3,000,000 square feet of lumber within 1¼ miles, and the mining town of Pioche for a market. The prevailing conifer species suitable for timber are the pines (*Pinus ponderosa* and *contorta*), the spruce (*A. Douglassii*), and the fir (*Abies Engelmanni*).

Summit Creek heads at the apex of the alluvial summit that separates Little Salt Lake Valley from the one to the south, and may be cited as an instance of an accumulation of detritus, leading to the creation of a sub-inclosed basin.

Groves of aspen alternate with patches of pine, partly valuable for timber, along this plateau, between Little Salt Lake and the Sevier, the volcanic cap still continuing to the southward; while sandstone cap occasionally appears, underlaid with lime. Fine specimens of fossil pine leaves and cones are here obtained. Many marine shells collected, and a new species of fir noted. Sundown Valley discovered and named. Usually volcanic material appears on the surface of the Colob plateau, with occasional limestone, sandstone, and shale. There is a fine growth of grass and groves of quaking aspen. The pines and firs disappear to the southward toward the valley of the Virgin River.

The country to the southward becomes more open and level along the main ridge. Fine water and grass noted on every side. The co-operative Mormon herd of Cedar grazed in this vicinity a distance of nine miles from the settlement. The ground still continues volcanic, with here and there points of sandstone, limestone, and shale, the latter profuse with marine shells, similar to those noticed east of Fairview, with an added bed of fossil oysters three to four feet thick. Skirting the rim of the plateau a break in the wall is finally found, and the train taken down into a box cañon along a descent having an angle of fully 55 degrees at the head of Le Verken Creek.

The summit of the southern rim, at an altitude of over ten thousand feet, affords one of the finest panoramic views then witnessed (1872)—the Virgin River lying at our feet, the Colorado Cañon in the distance, plateaus, cañons, and mountains to the east, mountains high and frowning to the north, and the mountains and desert to the west and southwest, the ranges bordering the Colorado, especially the Virgin. Below us lay the brown and black bristling ridges of the eroded mesas that for grandeur of beauty and desolation of appearance far surpass all that words can express. Clambering along the cliff, and while securing a large haul of fossils, the crisp edge of coal crops was noticed, and prospecting which a 12-foot vein of dense bituminous coal, having both above and below a bed of shale 15 to 18 inches thick, was found, with petrified wood strewn in many directions.

Fossils were found in sandstone near head of north fork of the Virgin and volcanic cap on the ridge leading to the head of the Sevier.

Clumps of heavy pines were seen in the cañons leading to the Virgin from the north; with fine bunch-grass and water here and there. The Sevier heads near the summit of a black volcanic peak to the south of the head of Coal Creek. Following the cañon to the northward the eye soon rests on a beautiful lake, nestled in the mountains, fringed by the sward of an encircling valley, and set like a gem in the green verdure rising from the slopes on either hand.

This lake is formed by the damming of the opening of the valley by black piles of vesicular lava, forming a miniature inclosed basin at the head of the Sevier. Clambering over the rough lava by the aid of a blind Indian trail, we suddenly emerge upon a handsome glade-like valley, in which springs up, as if by magic, a creek fully 25 feet wide.

This is known as Mammoth Spring, that breaks out from a considerable depth below the volcanic bluff, and gets its water in major part from the reservoir lake. Forests of heavy pines now appear along the valley of the headwaters of the Sevier.

The fields of basaltic lava skirted are about 25 miles long and 7 to 10 miles wide. These beds are intruded through the sedimentaries. The fork leading to Panquitch Lake (3½ and 1¼ miles) is reached by skirting lava fields and winding through forests, when a road is found and followed to the settlement on the Sevier. Duck on their migrations southward (September 30) were noted in large numbers, as well as trout in abundance. Indian and other cattle were found grazing in large numbers in the glades and valleys near head of Sevier.

The road from Panquitch to the south is followed, and a summit reached leading to Long Valley at the head of Virgin River. The actual heads of the Sevier were found to be multiple and fan-shaped. Sedimentaries, with edges facing southward, mark the transit from the drainage of the Sevier to that of the Rio Virgen. Coal is noticed cropping in a decided manner at lower end of Long Valley. Alum and saltpeter are also found here.

Large pines were observed in forest form near the summit leading to Virgin River. Corn, wheat, rye, and a few vegetables can be raised at this altitude. Passing to the basin of Virgin Cañon, walls of 200 or 300 feet are encountered. Volcanic cap on the south and limestone on the north are visible from Long Valley. Camp was made at a little stream leading to Virgin River, heading to the north at a distance of about 2¾ miles, in red limestone. The topographic relief between basin of Sevier and the Colorado, in this vicinity, is rigidly marked by bluffs named indiscriminately Pink and Vermilion. Coal croppings noticed along Paria and Kanab Creeks. The valley of the Virgin River is followed to the main rendezvous at Toquerville.*

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*NOTE.—In the area covered by the work of this year no timber of value except pine, spruce, and fir was found, the most extensive forests being on the Great Colorado Plateau. As the timber of the Government upon these tracts of land is subject to depredation from settlers and squatters, the sugges-

SCENE AT MOUTH OF CAÑON OF THE VIRGIN RIVER NEAR SHONESBURG UTAH.

(WRIGGLE TRAIL AT THE RIGHT.)

1872.

Plate IV is from a sketch made by Mr. John E. Weyss, at the mouth of Virgin Cañon, near Shoonesburg, Utah, after the dangerous descent of the so-called Wriggle trail in one of the routes through the Virgin River Valley in 1872. Six miles southwest of the settlement called Mount Carmel, the route, known as the Elephant road, connecting the settlements above and below the Virgin Cañon, ascending the plateau, leaves the river valley, following a due south course. Our party left this road, near the summit, following a dim trail, running sensibly parallel to the bed of the river (which here begins to cañon), thence westerly, passing a sandy valley, traversed by deep ravines, coursing toward the cañon of the Virgin. Seven miles brought us to the foot of a high mesa, at which point the trail disappeared, it being necessary to accomplish the ascent *en echelon* by scaling the successive beds of sandstone.

This climb was impracticable for the pack animals, therefore a hand portage, to the very summit, of stores and equipage became necessary. This ascent, begun at about 1 p. m., consumed the whole of the afternoon, and the sun had sunk when the party reassembled on the crest of the plateau.

The train camped on the summit without water after a hard and dry day's march, from which both men and animals were suffering. It was therefore concluded to advance with picked men to the valley below to secure water for the suffering party. After passing a shelf of bare, smooth-worn rock at the mouth of the descent along which it was necessary to slide at will for from 20 to 22 feet, the prints of Indian ponies became discernible, and a blind trail made its appearance.

Regardless of the roughness, and threading the way among rock and *débris*, the descent is begun, soon a narrow shelf of 10 to 12 inches wide is reached, overlooking a deep and dangerous gorge, leading to an abyss of darkness, which was passed after dusk. For a distance of 1½ to 2 miles the trail, or rather the want of a trail, followed the upturned strata edges, winding in and out of projecting ledges, which could only be skirted in the darkness on hands and knees. It was near 10 o'clock when the small party reached a little trickling stream that soon joins the main river, which was quickly followed after quenching our thirst, on a prospecting tour for the first settlement down the river, which proving to be a few houses (called Shoonesburg, elevation 3,920.5 feet), was reached about 11 p. m., where terms were soon made with the presiding elder, who, besides promising immediately a cup of coffee, invited us to the soft side of a haystack for the night, and into a little vineyard near at hand, wherein the moon acted as a most fascinating guide in pointing out the plump, full-grown, well-ripe clusters of grapes, of the finest cultivated varieties, including the To-kay. Our coming created a sensation, as no party, except on foot, had ever been known to pass this route, unless it were an adventurous mail-rider with a trusty-led mule, in case of great emergency. Nothing short of considerable blasting could render the trail passable even for pack animals.

The situation of Schoonesburg is exceedingly romantic. Mesa-locked as it is by the huge, steep escarpment of the semi-plateau forms at either hand, it lies ensconced in a little opening, a sparkling gem, dropped as it were through the mountains upon

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tion was made in the annual report of this year, that by legal enactment or otherwise the Government should give protection to its interests and the interests of future settlers in this regard; a suggestion since acted upon through the General Land Office.

the desert. The elevation of the plateau or summit of the Wriggle trail is approximately 2,100 feet above the valley of Virgin River, or approximately 6,020 feet above the sea.

Plate V, Dripping Pool, or Fern Spring, is situated in Kanab Cañon, which narrows at this point so that the sun only reaches its bed for two hours during the day.

The water of the pool, or spring, comes from a tiny lateral stream, intercepted by the erosion of the cañon, which, containing mineral substances, has deposited a projection extending about eight feet from the wall of the cañon, which is covered with ferns (Maiden's Hair—*Adiantum capillus Veneris*) and small flowering shrubs, that being constantly humid, and dripping even, form both a direct and mirrored object of great beauty. At a little distance toward the head of the cañon a spring breaks out from the foot of the cañon wall, at a temperature of 60° F. The walls at the right of the view are typical of the Colorado Cañon series, of which they form a part.

Plate VI represents a typical scene from a point of the rim of the plateau edge that divides the waters of the Sevier River from those of the Colorado, in Utah. It is approached from the east fork of the Sevier River, near the southern extremity of Plateau Valley (see Atlas, sheet 59), by leaving the river near its entrance to the hills and following a more southward course along a valley surrounded by low hills. A gentle ascent of three miles is abruptly terminated by the precipice leading to the head of Paria Creek.

These bluffs, consisting of parallel layers of soft red sandstone, fall perpendicularly to the eastward, forming the boundary within which lie embedded the headwaters of the Paria. The foreground includes fragments of the main mesa rim, the distant view being the mesas that line the Colorado, the Navajo Mountains rising to a somewhat conical summit in the east.

The sketch from which the engraving was taken was made on the ground by Mr. John E. Weyss, for many years connected with Western explorations and surveys under the War Department.

Plate VII is an engraving from a sketch made by Mr. John E. Weyss at the ford on the Colorado River, known as "El Vado de los Padres," the (Crossing of the Fathers), from its first having been attempted by white men in 1776–'77, when a Spanish party under Padre Escalante crossed it in an outward trip from Santa Fe to Great Salt Lake Valley and return. This crossing was approached by the party under Lieut. Marshall, U. S. Engineers, by the old Navajo trail leaving Paria settlement (the last point of civilization in Utah), ascending a sandy and barren plateau, and following in a southeasterly direction the foot of the high plateau leading out from the Salt Lake Basin rim to the Colorado River. At a distance of 20 miles a mass detached from the plateau, and called Gunshot Mountains, is attained, whence passing a narrow slit-like gorge, 10 or 12 feet wide, appears an amphitheater, out of which a trail issues again upon a rocky plain, reaching after a little more than a mile, a deep narrow cañon (represented in the foreground of the view), which is descended over precipitous rocks, the debouche from which opens upon one bank of the Colorado (elevation at ford 3,193.3 feet). Slight water ripples mark the line of the ford, which is reported as the only one for 300 miles, which of itself is only practicable, and then on horse-

U.S. GEOGRAPHICAL SURVEYS WEST OF 100TH MERIDIAN.

VOL. I. GEOGRAPHICAL REPORT.

PLATE V.

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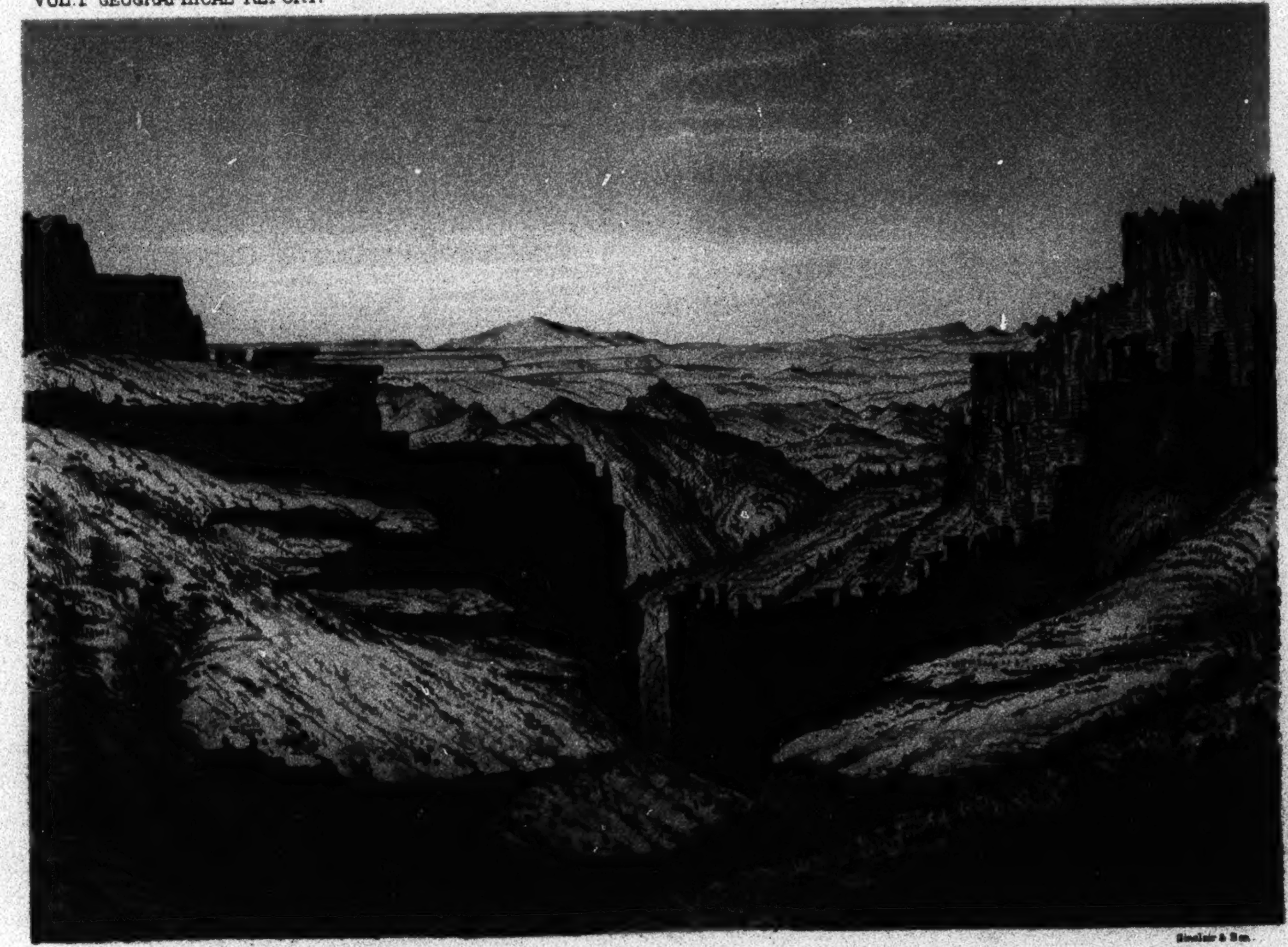
DRIPPING POOL. KANAB CAÑON
NEAR THE COLORADO.
1872.

U.S. GEOGRAPHICAL SURVEYS WEST OF 100TH MERIDIAN.

VOL. I GEOGRAPHICAL REPORT.

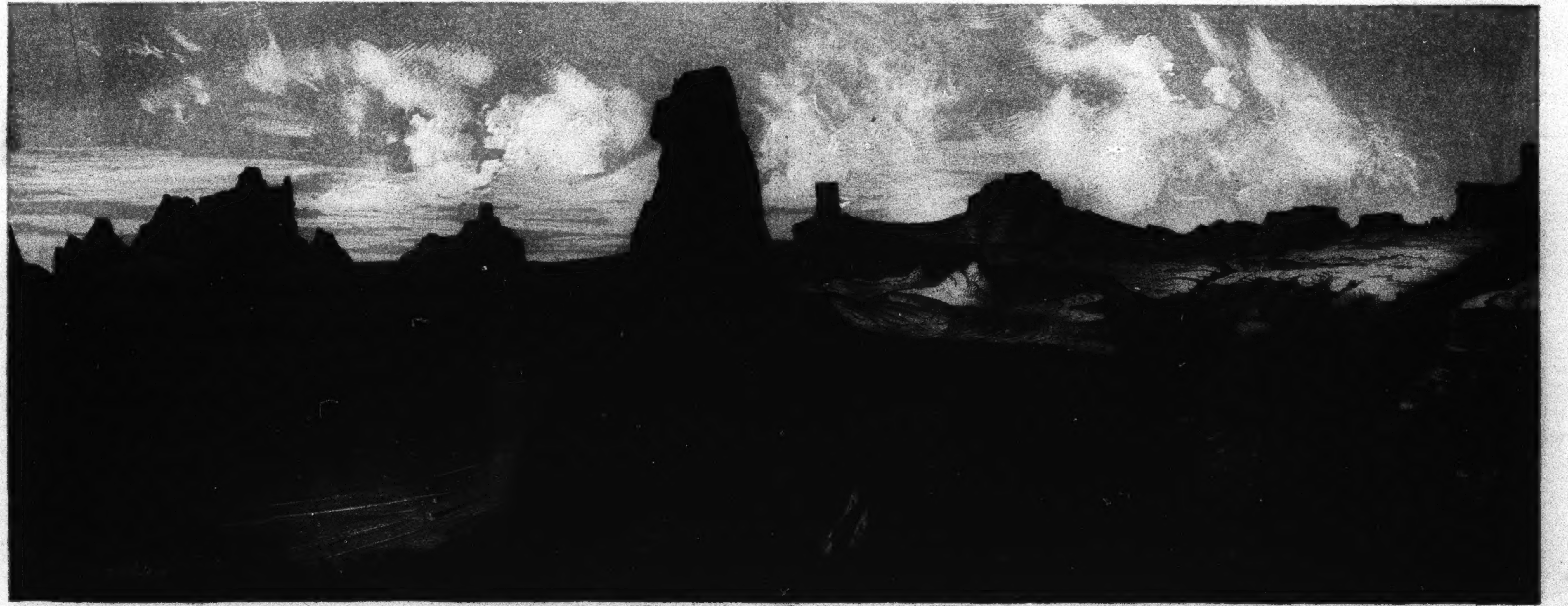
PLATE VI



Sinclair & Son.

HEADWATERS OF PARIA CREEK FROM RIM OF THE BASIN-SOUTHERN UTAH

1872.



EL VADO, DE LOS PADRES, COLORADO RIVER.

1872.

back, at low-water stage. It will be found marked on atlas-sheet 67, at approximate longitude 111° 17' west from Greenwich, and latitude 37° 01' north. This is no longer of practical importance since a ferry has been established at the mouth of Paria Creek. The scene is one of remarkable grandeur and almost unique in its loneliness.

The early explorers whose tracks entered or crossed this season's area are the following, according to date: (1) Padre Escalante, 1776-'77, from Utah Lake southward, nearly through the center. (2) Frémont, 1845, along his southern route to California. (3) Stansbury, 1849-'50, in the explorations and surveys ending at Great Salt and Utah Lakes. (4) Gunnison, from valley of Green River to the Sevier Basin. (5) Lieutenant Beckwith, Pacific Railroad surveys along the thirty-ninth parallel. (6) Lieutenant Simpson, both in his outward and inward routes from the valley of Great Salt Lake to Carson, Nev., and return in 1859.

The public-land surveys that had been extended over but little of the southern and western portion of this area have now (1887) carried their subdivision over a much larger portion, especially of the agricultural, grazing, mineral, and timber lands.*

The several tribes of Indians found within this section were: (1) The Uintah Utes, (2) White River Utes, (3) Pahvants, (4) Pah-Utes, (5) Seviches, (6) Hualapais, and (7) Apache-Mohaves. Of these the Pahvants, Pah-Utes, and Hualapais were friendly; the Utes and Seviches semi-friendly; the former being engaged in a raiding expedition that required the presence of troops to drive them back upon their reservation at Uintah and White River agencies. Therefore it was necessary to campaign east of the Wasatch in the presence of these Indians, who were evidently in no friendly mood, with a small party of nine persons. The only one who failed us in this emergency was the Mormon guide, a local judge (!), from one of the valley settlements. Chief Douglas, of the White River Utes (afterwards so intimately connected with the Meeker massacre of that agency), together with the war chief of the Uintahs (Tabby), interviewed us at the camp near Provo, and subsequently left for the mountains, the safe scene of all Indian murders and ambuscades, in the same direction that we were to follow.

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*NOTE.—Surveys by General Land Office up to June 30, 1886, had subdivided 12,910,540 acres, or 20,173 square miles, in Utah, out of an estimated total of 84,476 square miles for the whole Territory.

The Pah-Utes inhabit the country about the heads of the Sevier River, Santa Clara Creek, and parts of the Muddy and Virgin Valleys. The Utes, in several bands, inhabit the range in Grass Valley and other valleys about Fish Lake and in the San Rafael.

The Scheavwitz live along the valley of the Colorado, in the Grand Wash, and cañons and valleys leading into it. The tribes encountered worship the sun, and agriculture is scarcely known among them.

The Mormon flocks and herds dot the foothills of the valleys of the Sevier River and its tributaries, and gradually are expanding southward, already (1872), preparing to cross the Colorado River at the mouth of the Paria for settlements on the Little Colorado. The policy of the Mormons has been to discourage mining, and it is only since the Gentiles (so-called) have entered the country for its subjugation and settlement that it bids fair some day to become the theater of a very important, prominent, and permanent mineral industry, especially as railroad communication north, south, east, and west is now only a question of the near future as population increases. The opening of the silver mines calls for coal and iron, and the latter, rich and plentiful, must some day command more than a local market. In 1872 the surface had been only touched in any of the localities coming under inspection, and it was too early to state with clearness the true character of the ore deposits; enough was seen, however, to justify sanguine expectations, especially at the Ontario mine, that has since been so large and regular a producer of bullion. Coal in Sam Pitch and Castle valleys and on the northern fork of tributaries to the Virgin River promised to produce an economic and reliable coke.

The principal commercial routes through the 1872 area were the Utah Southern Railroad, from Salt Lake City to near Provo, thence a stage line to the southward via Fillmore to Pioche, with a branch to Beaver, Toquerville, and Saint George. The Denver and Rio Grande, now extended to Salt Lake City, enters the area of 1872 along the route originally selected by Gunnison, and upon which a military wagon-road bearing his name was constructed.

There had lately been a rude wagon-road constructed to the mouth of Paria, a creek where the well known Mormon desperado and leader of the

Mountain Meadow massacre, Maj. John Lee (who was later shot standing in his coffin to expiate his crime under the law), had established a ferry for emigrants passing southward. The next ferry on the Colorado was at the mouth of the Virgin, a new thoroughfare for miners and others to Northwestern and Western Arizona. With the exception of the route to Pioche, there was no east and west route of communication—a more southwesterly one across a wide arm of the desert, known as the Los Angeles route, was, however, still employed by hardy bands of prospectors and occasionally by emigrants.

Of the precious and economic minerals the following were observed, viz, gold, silver, copper, lead, iron, sulphur, gypsum, salt, chalk, bismuth, coal, &c. The southwestern portion of Utah has its silver, coal, and iron mines of great extent. The mineral resources of the several mountain ranges have been prospected, which has led to developments in several prominent mining districts and the cultivation of arable ground in the cañons adjacent for local supply.

By the use of canal irrigation, in a rather primitive way, the Mormons have been able to make the desert smile with productive fields, gardens, and grass plots, the area brought under successful and safe cultivation increasing from year to year. However, frequent droughts make it unsafe to attempt to irrigate the semi-mesa benches of loose, porous soil, while large and systematic schemes of irrigation may yet increase to a considerable extent the available acres, especially in those basins fed by the Wahsatch system of mountain ranges.*

Many of the routes of the season were along the eastern rim of the Great Interior Basin, the exact limits of which were more clearly defined, and thus commencing with the expedition of 1871 and concluding with that of 1878, the entire perimeter line of this peculiar inter-plateau, land-locked structure (the "Great Interior Basin" of Frémont) was traced and demarked, with the exception of a small part of its northern boundary.

The portion of the Great Interior Basin visited this year is by far the best watered and has really proven a land of promise for the Mormons, and is susceptible of considerable increase in settlement. Fourteen thermal or mineral springs lie along the routes of travel, with temperature varying from 72° to 185° F.

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* NOTE.—The conclusion was reached that as the region of perennial snows in the western mountains are few in number and trifling in extent, the areas which can be permanently irrigated are largely limited by the absence of this source of water supply.

The geological examinations furnished matter of particular interest. In general characteristics the northwestern portion of the region surveyed showed narrow mountain ridges, a part of the Cordillera system, composed of crushed and altered Paleozoic rock, alternating with rather broad valleys half filled with waste of the mountains. In this region granitoid rocks are of frequent occurrence, with many metalliferous veins. Considerable areas are occupied by lavas. The southeastern portion is the Upper Colorado plateau system, the rocks ranging from the Tertiary to the Devonian. The strata are undisturbed and easily observable in the numerous and extensive cañons. Coal in inexhaustible quantity, and widely distributed, is found in this region.

In the Schell Creek Range, about White's Peak, Nevada, terminal moraines of five or six glaciers were found, descending to 8,000 feet in altitude. On a flank of Union Peak, Nevada, are moraines, and an alpine lake, and from Old Baldy Peak two moraines, of which one contains a lakelet at an altitude of 9,000 feet, are to be seen.

The glaciers of this region seem to have been confined to the high mountain ridges, and the evidence is against general glaciation.

The limits of an ancient fresh-water lake which covered Great Salt Lake and Desert, Sevier Lake and Desert, and in all an area of 18,000 square miles, or about equal to that covered by Lake Huron, were carefully examined. This lake, for many reasons given in the appendix to the Annual Report for 1872, is supposed to have marked a temporary climatal extreme, contemporary with the general glaciation of the northern portion of the continent, and at high altitudes, local glaciation in the western mountains.

Deposits similar to those of recent time are discovered beneath those of the period of the great fresh-water lake.

The outlet of this lake was towards the Columbia River. From the observations made, a map has been constructed showing the restored outlines of the ancient, though geologically recent, lake, named Lake Bonneville.

At Provo a species of whitefish, native of the fauna of Puget Sound, was discovered to be abundant; and this fact may be taken in corroboration of the theory of the outflow towards the Columbia River of the former Lake Bonneville.

The introduction a few years previously of the Eastern quail was found to have resulted in a considerable increase throughout the section of country where first set at liberty, and it was deemed practicable to successfully introduce salmon, shad, and alewives into the tributaries of Salt Lake.

General collections in natural history were made by Surgeon H. C. Yarrow, who rendered most valuable service in this direction, as did Mr. Henshaw in ornithology. The former states the collections of 1872 to have been as follows: 1,426 invertebrate fossils, 800 bird-skins (approximate), a large number of mammals, several hundred fish, 16 species new to science, 5,000 reptiles, insects, shells, plants, &c., and also a number of Indian crania, and a lot of ethnological specimens. These specimens, after having been reported upon by eminent specialists, were deposited with the Smithsonian Institution for the use of the National Museum.

Excavations were made near Provo, Beaver, and Paragoonah, Utah. At the former a number of stone mills, pestles, arrow-heads, pottery, bones of animals, several domestic implements, and an almost perfect skeleton were discovered. Time did not permit of more than superficial examination, with slight excavations among the 400 to 500 mounds near Paragoonah. Both of these localities are worthy of a more extended search.

Ute and other vocabularies were collected. All that has been accomplished in archæological researches appears as so much clear gain in addition to the results for which the survey was primarily organized, *i. e.*, the topography of an extended area.

The topographic detail secured by this expedition will, in the main, be found reduced upon Atlas sheets Nos. 49, 50, 58, 59, 66, and 67.

EXPEDITION OF 1873.

The area entered this year aggregates approximately 72,500 square miles, distributed as follows: Arizona, 20,175; Colorado, 19,892; New Mexico, 28,632; and Utah, 3,801 square miles. The main body of the expedition operating from Santa Fe, N. Mex., confined its labors to the basins of the Rio Grande, de Chelle, Little Colorado, Gila, San Francisco, and Salt Rivers, and the numerous creeks entering them, especially about the sources of the four latter streams. Sections under Lieutenants Hoxie and Marshall; United States Engineers, operated independently of the main body, the former from Salt Lake City as an initial point, and in the basins of Great Salt Lake, Sevier, Green, and Large and Little Colorado Rivers, while the latter, entirely detached, set out from Denver, confining itself principally to the basins of the Arkansas, Gunnison, and Rio Grande.*

The streams which flow through the principal mountains and valleys furnish along their banks natural and artificial routes of intercommunication and exit to exterior areas, details of which are to be found on Atlas Sheets Nos. 52, 59, 60, 61, 62, 67, 68, 76, 77, 83, and 84 (see scheme of Atlas Sheets for United States, and description of maps in Appendix B).

The important cañons, other than the Grand Cañon of the Colorado, are, those found at the heads of the Gila, San Francisco, Bonito, and Salt Rivers in Arizona and New Mexico; of Paria Creek and Castle Valley in Utah, and the Gunnison in Colorado.

The routes of early explorers traversing the 1873 area are found to be eleven in number, as follows: (1) Padre Escalante, from Santa Fe to valley of Great Salt Lake and return; (2) Lieutenant Pike, 1807, from near Bent's Fort, on the Arkansas, to the Rio Grande, near junction of Conejos Creek; (3) Captain Frémont, in his routes westward, along valleys of Upper Arkansas (1844) and Upper Rio Grande (1845); (4) Lieutenant-Colonel Cooke, 1846–'47; (5) Lieutenant-Colonel Emory, from Rio Grande westward, 1846–'47; (6) Lieutenant Simpson, to Cañon de Chelle and return (1849); (7) Captain Sitgreaves, from Zuñi villages westward to Colorado River, 1851; (8) Captain Gunnison, 1853, from San Luis Valley to that of Gunnison River; (9) Lieutenant Whipple, Pacific Railroad Survey along thirty-fifth parallel, 1853–'54; (10) Captain Beckwith, Pacific Railroad Surveys, 1854; and (11) Lieutenant, now Brevet Major-General, Parke, eastward to Fort Fillmore, Tex., from Colorado River, Pacific Railroad Surveys, 1854.

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*Note.—The following are the main routes followed by the officer in command: By stage to Santa Fe, N. Mex.; thence to Fort Wingate; thence northward beyond Old Fort Defiance and return to Wingate; thence to Camp Apache, via Zuñi and Colorado Chiquito crossing; thence, via main fork of White Mountain Creek, to summit of Sierra Blanca Range; thence north and eastward, south and eastward, and southward returning to Camp Apache; thence to Fort Wingate and Santa Fe, and thence to the railroad at Pueblo, Colo.

The public-land surveys during the period between the examination on the ground and the issue of the final maps have been prosecuted with vigor in many of the regions (especially in Colorado), and while connection was made in all practical cases on the ground, advantage has also been taken of the later sectionizing details, if any, to indicate new roads and settlements and other later permanent improvements.

PARTIAL ITINERARY.

Fort Wingate, N. Mex. to Fort Defiance, Ariz., &c., July 21, 1873.—Camp was made about 1 mile east of wagon road, about midway to Old Fort Defiance (Indian agency of the Navajoes) at Rock or Sheep Spring. The water seeps from the upper surface of a soft shale, underlying a red sandstone, with a slight dip to the northeast. This latter bed always carries more or less water on account of its permeability. Mexican bull teams carrying Government stores to the Indian agency were noticed encamped on road at Stinking Springs (so called from the odor of sulphureted hydrogen); the dry bed of the Puerco was passed at a bridge a little further on, when, leaving the valley along a northwest course, Rock Springs are reached, at a distance of about 22 miles. The next day camp is made toward evening at the old post of Defiance. Subsequently a detour about 15 miles to the north and east is taken to the garnet and ruby fields.

A ride of 10 miles brings one near the head of the drainage line passing through Defiance. A little rounded knoll in the valley below, covered with a reddish soil, interspersed with conglomerate pebbles, shows many garnets on the surface. The formation of the dry interior valley, marking a point of the garnet beds, shows on either side the persistent and familiar red sandstone bed, resting conformably upon mountain limestone, the prominent feature of the frequent mesas of the Little Colorado basins. Underlying it is found in many of the explored horizons a strata of bituminous coal. The extent of this apparently immense bed, as yet but imperfectly traced, covers thousands of square miles in Northwestern New Mexico and Northeastern Arizona. Scattered through the valley in question, often on the surface of burnt basaltic lava in loose débris, evidently washed from a bed of greenish, soft tufa that persistently breaks through the nearly horizontal sedimentary strata at varying angles, at horizons within the reach of the eye, were quantities of garnets and aqua-marines. A small emerald was also found on the surface, and rubies of fine texture and color have been found in the same locality. Were it not for the dearth of water, coupled with the fact that the points at which these gems have been discovered are on a Government reservation, there can be no doubt but that this locality is worthy the search of intelligent prospectors versed in the alluvial and fixed formations known to furnish precious stones of the varieties named.

Fort Wingate, N. Mex., to Fort Apache, Ariz., August 5, 1873.—Leave camp at 6 a. m., via Zuñi Villages and Little Colorado, for one of the survey camps at Cold Spring, northeast of Camp Apache.

The route crosses the spur-like divide of the southern branches of the Puerco and the northern tributaries of the Zuñi, one of the obstructions of a route from the Rio Grande in Southern Colorado to Eastern and Central Arizona.*

The route is frequently relieved by little park-like openings, fringed or surrounded by irregular growth of forest pines (*Pinus ponderosa*) on either hand, with fine grassing (bunch and grama grasses predominating), with also a wealth of shrubs and flowering plants of a semi-tropical character, water alone being wanted to perfect the scene. Oak groves with mistletoe growth were occasionally noticed, and fir usually at elevations above 8,000 feet. At Nutrias, a Zuñi outpost, is found a little pueblo town occupied by Zuñi Indians, which, together with those of the Zuñi village proper and that of Ojo del Pescado and Ojo Caliente, make four of the seven sites that once were settled by these village Indians, the ruins of three others being now found near Deer Springs (Ojo Benado), Tule Springs, and at an adjacent point on the line between them and not far distant from the former.

Here are noted large herds of goats and sheep, the property of both Navajoes and Zuñis. Timber is still abundant, while it becomes dwarfed at Pescado and almost absent at Zuñi proper. Below 7,000 feet in this section of the plateau region timber is scarce, becoming abundant at 8,000 feet, and so continuing to an altitude of fully 10,000 feet.

The route leads out of the Nutrias Valley along denuded portions of the plateau system (sand and limestone beds, the equivalent of those in the Puerco Valley predominating) into that of the Zuñi proper, reaching the direct road to the villages, two miles west of the Pescado.

The artemisia of the Western plains was frequently noticed with piñon pine and scrub cedar prevalent, interspersed with heavy pine timber at intervals, especially at higher altitudes, along the day's march.

August 6, 1873, *en route to and at Deer Spring Camp.*—A few miles brings one to small irrigated fields at Black Rocks. Water appears at crossing of the Zuñi near the pueblo (found slightly alkaline, the water in a well upon which the town is built proving sulphurous). Most of the cultivated patches were of corn, while little groups of squashes and melons, beans, and wheat were noted. In the little gardens near the town, onions, tomatoes, and caraway were seen. They were watered by hand by the women from large ollas carried on the head, some of which were ornamented with considerable taste. The best corn fields were watered by irrigation ditches from the river (nearly dry at this date). Most of the Zuñi herds were at the Nutrias and at Pescado The principal beast of burden is the jack, while horses are also used. The then governor was Pedro Pino, from whom many items of interest were gathered.

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* NOTE.—Since the construction of the Atlantic and Pacific Railroad, Northeastern Arizona is made more accessible from Holbrook Station, on the Little Colorado.

The grant from the Spaniards, or rather the Mexicans as asserted by Pedro Pino, covers the following area: Bounded on the north by the dividing ridge between Zuñi River and the Puerco, on the east by the summit of the Zuñi Mountains, on the south by an east and west line through the Salt Lake, and on the west by the Little Colorado.

Many decades since a great storm came and flooded the valley so that their present site was uninhabitable, and it became necessary to take to the mesa, where they lived temporarily (old maps show the position as on a mesa bluff).

Their traditions are to the effect that they had always lived in the same spot, and that three other pueblos found to be, one at Ojo Benado, a second a short distance to the south and east, a third at Tule Spring, now in ruins, were once inhabited.*

The valley is left at a southwestern exit. There is a well-marked rainy season at Zuñi in July and August. Ojo Caliente, the fourth Zuñi pueblo, was noticed in the distance, as also fields of corn, apparently growing out of the sand, but in reality the sand was only a drift covering a dark alluvial earth, found underneath. Black eruptive basalts were observed at various points on the march; otherwise the lime and sandstone of the plateau system predominates, the latter approaching a quartzite. It is stated that the winds (from southwest) of the lower Little Colorado and Zuñi in April, May, and June are almost hurricane-like and incessant. Young corn is blown up by the roots, against which the Zuñis protect the tender growth by branches of cedar placed to the windward.

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* NOTE.—The fact of there being these three ruins, and only that number being traditional with the Zuñis, was clearly pointed out to me by Pedro Pino during a long and careful conversation. That these villages are the actual "Seven Cities of Cibola" visited by Coronado in his famous expedition of 1540 appears quite probable. The narratives of the officers of the expedition and of historians of the times agree as to the exaggeration and deception practiced upon the Spaniards by the imaginative tales of Fra Marco de Niça, and describe the main of the seven cities at about 25 miles distant from a river where wild flax had been found (probably the Little Colorado or Flax River), approximately the actual distance from Zuñi to the bridge at the Colorado Chiquito crossing. (See Atlas sheet 76.)

The position with regard to Tusayan (probably the Moquis villages) and the Province of Tigeux (probably the pueblos of the Rio Grande north of Albuquerque) and Acuco (probably Acoma), as well as Quivira, corresponds quite well with the historical record of the marches of Coronado and his captains. (See Smithsonian Report of 1869, pp. 309-342. Seven Cities of Cibola, by Simpson.)

The late General Simpson, in the article in question, quotes the following as of opinion that the Zuñi pueblos were the seven cities: Gallatin, Squier, Whipple, Turner, and Kern. He also arrives at the same opinion from a somewhat extended examination of the Spanish authorities, while Emory and Abert (as stated by Simpson) incline to locate the seven cities at and along the plateau southeast from Mount Taylor, counting Acoma, the most southerly and isolated as to position and language, as one. and Laguna, Cubero, Poblazon, Pojuate, Moquina, and Cibolleta in order to the northward. The late Mr. Morgan refers the site of the seven cities to the ruins found in the valley of the Chaco. The weight of evidence so far examined leads to the placing of their site at the Zuñi pueblos, and this conclusion is strengthened by its proximity to the valley of the Gila, which, it appears, was crossed near the ruin now known as the "Casa Grande," and called by the Spaniards (probably) "Chilcitalle."

The entire region occupied by the present and extinct pueblos having been embraced by the surveys of this office, their location will be found on the published atlas sheets.

Timber begins again, piñon and cedar on lower, and large pines at higher levels.

August 7.—At Cedar Spring, about 22 miles from the Colorado bridge, the first glimpse of the Sierra Blanca is had, which testifies also to an emergence from the persistent plateau so long the horizon.

The main peak, in somber blue, stretches well into the horizon, while the verdure of the eastern slope of the range does not, at so great a distance, appear so dense as that of the western noted from vicinity of Apache in 1871.

These slopes, however, unlike their counterparts (the eastern) in the Sierra Nevada, face on smiling valleys and glades well grazed and watered, in a section of rare luxuriance, and marking a grand oasis as compared with the adjacent and more sterile portions of the valleys of the Rio Grande, Gila, Salt, and Little Colorado Rivers.

Twelve miles beyond Deer Springs the desert-like waste of the Colorado Chiquito, and the familiar greasewood, sand-grass, and sage appear, while the piñon pines even becomes dwarfed and few. After crossing the Quemada, made muddy by the late rains, the Little Colorado is reached after a few miles. It is from 8 to 10 feet wide, with its surface current 6 feet below the banks.

August 8.—Near Cave Springs. A fine spring breaks out from a volcanic bluff (basalt) and flows into a small, well-grassed valley, containing both bunch and grama; nestled among the mesa-ridges, scattered piñons appear, and from this point until the Mogollon forest is reached grazing and water are plentiful. A mineral spring was noticed to the south of the road, some 10 miles toward Apache, where the more rolling hills have become covered with luxuriant bunch grass and occasional clumps of pine.

Toward the close of the march the road reaches the timber fringes of the Great Mogollon forest of the San Francisco Plateau.

August 9.—En route to and at Oak Grove Camp near Camp Apache, the road runs through a beautiful pine forest, with occasionally little groves of white oak (*Quercus undulata*) and a few black walnuts of small size. These oaks were abundant, of vigorous growth, exceeding 20 feet in height, with a wood solid and close grained. Bunch and grama grasses were abundant in all the glades or openings which occasionally give a most delightful variation to the immediate landscape.

A climb upon a peak near the route reveals a partial view of the Salt River Basin and the connection of this forest with the one explored in 1871 to the south and eastward of San Francisco Mountains. This peak is a crater cone, as are so many along the northern end of the Sierra Blanca, an entirely volcanic range. The first view of the sedimentary breaking out from beneath the lava flows is found near Cooley's Park, some 8 or 10 miles from Apache. Camp is made in a little oak grove opening, where running water and grass in abundance of themselves afford repose when compared with the reverse picture so frequent in the more desert portions of the trip.

August 10.—Reaching Camp Apache, Arizona, an excellent and descending road leads into the branch of the White Mountain Creek, upon which Camp Apache is situated. This stream is followed from a point near Cooley's Park.

SIERRA BLANCA REGION.

August 12, 1873. En route to and at Green Corn Camp, East fork of White Mountain Creek. Arrangements were completed for an exploration from Camp

Apache, as a base, to the eastward of the Sierra Blanca, and to include the heads of the East and North Forks of White Mountain Creek, the sourcesof the Little Colorado, San Francisco, and Bonito Rivers (tributaries of the Gila), and of the main fork of the Prieto or Salt River. Beyond, a few miles along the ravine of the East Fork, near Camp Apache, so far as could be ascertained, the foot of white man had never trod within these solitudes, and the magnificent expanse of more than 5,000 square miles of mountain, valley, glade, lake, and river lay before us, a true *terra incognita*.

The drawing of the Indians toward the West to agencies at Camp Apache and San Carlos, Ariz., and eastward to Forts Bayard and Tulerosa, and to the Cañada Alamosa, New Mexico, had left this a neutral zone, where Dame Nature ruled in all the magnificence of true simplicity.

The special party was so equipped that no obstacle or peril of mountain-path finding could impede its movements in any direction, independent of trail and regardless of the tangled forest or roaring stream. One of the objective points was the summit of the Sierra Blanca, from whence a mountain view unequaled by any within our territory, with the exception of those from the highest summits of the Sierra Nevada and Cascade Ranges, was anticipated, and the results far more than justified the expectation, for beyond description the view from this point (named Thomas Peak) was the most magnificent and effective of any among the large number that have come under my observation.

The route for the day was entirely through the valley bottom which gradually narrows, being surrounded on either side by reddish beds of argillaceous limestone in which fossils (presumably carboniferous) had been found. The mesa edges of the rolling plateau were covered with heavy pine of the species *Pinus ponderosa* (yellow pine) reaching heights of fully 80 feet, another variety (*Abies concolor*) prevalent in New Mexico though not growing quite as large, and having shorter leaves and cones. These trees quite approach the bed of the stream. Sycamores, mountain oak, and black walnut were also observed.

August 13.—The topographers of the party leave camp to ascend a peak to the north and east from which a fair view is obtained toward the head of the stream, which appears densely wooded with pine and fir timber. Here and there a small stream flows in from the north side, furnishing water for the cornfields on the surrounding mesas. On a small eminence was found the rough débris of an old ruin originally constructed of volcanic (basalt) material without cement, and strangely enough without pottery fragments in sight. The volcanic ground passed over proves to be *mal pais*, and a most serious obstacle to the passage of the train.

August 14.—It becomes again necessary to follow the bench on the northern bank of the creek, making one or two crossings exceedingly abrupt at almost impassable points.

Several springs are passed flowing from the base of beds of permeable volcanic conglomerate. The springs are usually large, forming little streams flowing at least four or five hundred yards.

The elevation gained was approximately 8,000 feet. The horizon was entirely above the sedimentary and in a basaltic rock cap.

No sedimentary was found of later age than the Carboniferous, the lava having descended to this horizon, The northern bank gives by far the best slope. It is accounted for on the supposition that the snow melts first on the north side of the cañon, thus giving a special character to vegetation. Strawberry and raspberry vines are seen. Camp is made at some springs densely surrounded by the most elegant evergreen of the Douglas spruce.

The fir region has not yet been reached, it being found at greater altitudes. Lakes were spoken of over the divide near the head of the fork, in regard to which the Indians have a superstitious fear, calling them the Holy Lakes, in which they say the divine mermaid dwells. Elk, mountain sheep, California lion, deer, antelope, wild turkey are known to be abundant in this range, and their fresh tracks were constantly seen.

August 15.—Early in the day a little stream was met, coming in from the north through a deep ravine from a mesa densely wooded that reaches to the bed of the main creek, the crossing of which was attended with the greatest difficulty, an extemporized raft being necessary.

Ascending the mesa it becomes necessary to contour and follow an extensive bay that makes in from the north. This is finally passed and a dividing ridge that comes in from the north gives a view of the head of two branches of the East Fork. Here it becomes necessary to descend into the ravine of the most northerly one and follow the stream to its source, and, ascending the slopes of the tortuous divide, a plateau bearing patches of fine bunch grass is reached. From this one looks down into the valley of the North Fork. The animals feast upon the rank and succulent mountain bunch grass.

August 16.—By ascending a high peak to the northwest it becomes possible to discover what seems to be a point at which the passage across the range can be made.

August 17.—A camp is this day reached near the summit of the Sierra Blanca. The reconnaissance trail of yesterday was followed in the direction of a low divide north of the principal peak. The grades improve, but the spruce timber continues almost impassably thick. Traveling about 5 miles brings one to the ridge, where a most remarkable panorama spreads before us of dense forests, interspersed with well-watered little valleys and glades covered with luxuriant grass and flowers, of lakes and running streams sparkling in the sun, all amphitheatered by the grim walls eastwardly by the Datil Range, a part of the continental divide, and also the Tularosa Range, with mountains to the southeast bordering the Gila, partly opening northward toward the Colorado. Water having been found near the summit, camp is established, and we push ahead to the main peak, where lies within our horizon a landscape view of the grandest scenery, interspersed with agreeable, home-like valleys, vales, and glades in nearly all directions. Outstretched before us lay the tributaries of seven principal streams, the true courses of which were unknown to geography, and only traced conjecturally on maps of this far-distant region, viz, the Colorado Chiquito, the Nutrioso Creek, the San Francisco fork of the Gila, the main head of the Prieto or Salt River, and the Bonito a tributary, and the north and east fork of White Mountain River. There are four main peaks within a distance of 10 miles, none of which had before been ascended by white men. The heads of the Colorado Chiquito and Rio Prieto present a stretch of valley lands far surpassing any I have before seen. The view of the landscape to the east is of the most marvelous beauty of form and color. Mountain, forest, valley, and stream are blended in one harmonious whole, in size large enough for a State, all falling within the horizon of one point. Few world-wide-travelers in a lifetime even could be treated to a more perfect landscape, a true virgin solitude, undefiled by the presence of man.

August 18.—I am satisfied that the valley landscape to the eastward had never been seen by any white men (1873). Perhaps here and there a few points had been touched while passing up or down at lower levels one of the streams above mentioned without giving any adequate view of the grandeur of the whole.

August 19.—Took leave of camp of over 9,000 feet above sea, and moving west of north follow the steep sides of the divide leading to a stream that proves to be the principal head of the west or main fork of the Colorado Chiquito. For some distance after the bed of the stream is reached spruce timber and aspen still continue, pine soon appears, after which comes an opening inclined at an angle of 40°, and covered with a heavy growth of fine bunch grass, interspersed with a variety of flowers in bloom.

For a little less than 2 miles the grass is of the old crop, then begins the new and juicy growth of the year subsequent to the burning over by fires set by the Indians. The creek here enters a small cañon, only to emerge into a broad open valley in the vicinity of the road that leads to Apache. We follow up this fork and reach a most beautiful open park that was seen from the mountains as apparently carrying a stream, which proves to be a fallacy, as the little meadows of the lower portion have flowing water only in spring after the melting snows. The general height of the prairie is a little less than 8,000 feet. A nearly northern direction was taken over a rolling, natural park-like country, more beautiful than any artificial or cultivated park could be, and the most attractive landscape ever encountered by me (1883).

The march was continued a little more than 5 miles, to a prominence named Park Butte, it being surrounded by the most beautiful natural parks. The butte commands the whole basin of the west fork, and through it one again traces the volcanic river to the north and west which limits the upper basin of the Colorado Chiquito.

August 20.—The train moves along the east side of the valley that surrounds the tributaries of the main west fork and soon crosses an almost imperceptible rolling divide to arroyos flowing in the opposite direction. It is soon discovered, however, that our line from the camp to Park Butte lay but a little to the west of a water-shed between drainage basins, the butte itself occupying one part of the line. Rolling arroyos that take their rise in the timbered ridges of this plateau soon converge and cañon upon reaching harder beds of volcanic flooring until soon water comes to the surface. The name of "Dotted Park" is suggested because of the numerous semi-mound-like structures planted almost regularly over its surface. It should be called either "Dotted" or "Island" Park. Bear, of the brown, black, and cinnamon color, are common in the eastern parts of the Sierra Blanca Range. The party continues to the eastward and suddenly emerge into a little valley that carries a tortuous stream to the eastward, which we cross and follow in its general direction. We are obliged to leave the valley of the stream mentioned, which flowing into a cañon soon turns to the eastward. The course is then left, and, skirting the timber to the north, we descry through an opening two bears feeding. A hunt is organized, but without success, the hunters sleeping out during the night. Meanwhile a 300-pound black bear had been killed after a hard fight. Here the openings are finely clad with nutritious bunch and other grasses. The soil is all volcanic. In the lower of these valleys, and below about 8,000 feet, crops could be raised without irrigation.

August 21.—Just at dusk last evening the party attempted to follow a trail, became entirely lost and circled on their tracks, but during the day reached a point near our camp of last night, where two forks come together, which proved to be tributaries of the main Salt River. A topographical party is dispatched east to determine the drainage of the water-shed upon which we had been traveling the greater part of the previous day. At this elevation spruce, pine, and aspen are found. Below us lies a beautiful valley at the confluence of the two streams mentioned, the soil of which at this altitude, and judging from the amount of humidity already noticed, ought to produce cereals, &c., without irrigation, a most valuable consideration in this section. Everywhere in the openings the most succulent bunch-grass is found in abundance. This section day by day presents beauties and practical features that rank it by far as the most attractive to agricultural settlers of any portion within the limits of explorations in my charge.

August 22.—The mal-pais soil, especially where it is nearly horizontal and without drainage, has become so thoroughly saturated that the mules sink belly-deep in many places. The narrow valley of the fork entering from the south is followed for 4 or 5 miles, running water being found for two-thirds of the distance. We then cross a rolling, timbered divide, that brings one into a similar valley that ought to lead toward the cañon found traversing to the southwest yesterday. This is followed for a time, then turning near to the north and west, pass over a sharp, peak-like divide, from which a view of the lake lying at our feet is obtained. It is about 1¼ miles in length and three-fourths in width, containing little islands well grassed. Its highest level is denoted by a slightly-marked beach line, fringed with a growth of shrub and apparently now at a medium stage. We found no more than 30 to 36 inches difference between that and high-water mark. The water is accumulated from the rains and is entirely of surface collections, slightly tinctured with vegetable matter. At its ordinary high stages it has no outlet and no stream enters it.

August 23.—The park in this vicinity is called Lake Park; an old beach line is reported 12 to 13 feet higher on the western side of the lake. We follow up the line of drainage leading toward the lake from the west, which at certain high stages may have forced the water over the head of this low arroyo.

The want of alkaline, saline, and other constituents in its waters must result from the large amount of percolation as compared with the amount of evaporation and the short distance traversed over a volcanic bed.

August 24.—A march of a little less than 5 miles, mostly through the timber, brings us to the Rendezvous Camp. This is snugly situated in a point of timber commanding the beautiful valley of the mountain stream that, rising in the cañon of the southeast flank of the Sierra Blanca, flows through park, forest, and valley to enter again a cañon prior to its confluence with the main stream, the Salt River.

August 25.—This day was spent in camp; parties go out here and there to the eastward and south. A party of Indians, mounted, is reported to have crossed 2 or 3 miles below. So far upon the route no trails except those made by game have been seen, and one would suppose that this very natural garden indeed had been neglected even by the Indians. No ruins are seen after crossing the range to the east, although Mr. Gilbert discovered some in the valley of the Little Colorado. These highland parks have been left to the animal denizens of the forest, to the bear, wolf, elk, deer, antelope, and other mammals, and to the gatherings of the winged families.

August 26.—It appears that the rainy season is nearly past, the heavens are partially covered in the heat of the day by moving, fleecy clouds that precipitate at intervals floods of rain, but the nights are usually clear.

No frosts were noted at this camp. I am satisfied that the extent of country surrounding the heads of Colorado Chiquito and Salt River and Rio Prieto will add to our climatic sanitariums one of the most delightful localities on the continent. The winds that have full sway lower down in the basin are here broken by the Sierra Blanca.

August 27.—A retrograde movement from this camp is made to reach the so-called Apache and Tulerosa trail. The route lay along broken ridges and through several little valleys, some with running streams and others without, until a very steep cañon lying ahead seems to indicate an approach into what is supposed to be the Bonito, but which proves to be still another fork of the Salt River. In a little opening the valley is crossed by a stream of considerable size. Here, as has been noticed in several other localities, the grass on one side of a stream will be new, juicy, and thin, because of the burning of the sward during the season, while on the opposite side, where no burning has taken place, the thick tufts of bunch grass spreading into beds offer more abundant food for the animals that have now to depend upon grass altogether for their support.

A trip to a divide to the southward shows nothing besides the peaks that have been noticed during the day and beyond which the main fork of Salt River is expected to lay. In this portion of our territory, where Spanish geographical names are still used, streams of all sorts and sizes have been designated by the name river.

August 28.—A party starts ahead from this point to reach Camp Apache, and the remainder follow them in their trail for about 2 miles. A pedestal-like peak, rising above the forest trees and commanding the course of the stream to the south, is ascended. The northern horizon commands in profile a characteristic view of the southern end of the Sierra Blanca, while to the northwest and northeast the regular, wooded slopes of what become, upon a close inspection, regular and broken mesas of the divide between Salt River and the Gila. To the east the Escudilla and San Francisco Mountains are well defined. Further to the southeast, put in bold characters upon the horizon, are high mesas or plateaus, with irregular edges, and one specially prominent range, because of its height, and still another, extending far to the southward, appear to close with the horizon in this direction.

To the west the four peaks of the Mazatzal and the Sierra Ancha limit the horizon. The mountains facing upon the San Pedro (the Pinal Range) give no point to the view of sufficient interest to determine their identity. To the southwest in strong relief appears what to my belief is the Chiricahua Range, although at such magnificent distances, when noticed from various compass points, it becomes difficult to dictate with precision.

One remarkable peculiarity of a view to the south while occupying a central spot in the trough between several meridional ranges is well illustrated by this station. The Chiricahua Range, that in reality trends northeast, appears to have a direction quite southeast, while a range of marked longitudinal extent to the southeast (probably the Mimbres Mountains) has apparently a direction of nearly southeast. This can only be explained on account of the inequality of refraction at different azimuths dependent on the character of intervening obstacles and to the vibrations of the atmosphere due to heated upward currents, apparently throwing objects out of a vertical plane.

August 29.—An early march brings us well ahead on the trip to Apache. A meadow-like opening is reached, that must debouch into one of the north forks of Salt River.

In less than 10 miles the cañon of the river in question is reached. None of the little park-like openings noted near the main peaks were tributary to this stream, that heads further to the southward and not as near the main peaks as the others. At this crossing no sedimentary rocks had yet become exposed, and no opening, so far as could be seen above or below, large enough for even a small camp.

In the meadow spoken of, wild flax was seen in patches; hence it is probable that the cultivated varieties could thrive. No more desirable location could be found for an elegant country residence than this meadow, nestled high among the rocky wooded bluffs, peacefully sleeping in beauty, with no sound save the sighing from the trees that line the entire horizon on every side, or mayhap the rustle of the roving wild animals of the mountain forest. The amount of water that can be utilized for manufacturing and mill purposes is sufficient for all that will ever be required. We are now once more among the pines that only reach a certain altitude, here not exceeding 9,000 feet. Spruces are growing scarce, while the aspen still remains, a native of many altitudes. Black walnut (*Juglans rupestris*, var. *Major*) of medium size are here observed. As was expected, the trail followed is a nearly latitudinal one, that has been traveled from time to time by Indians en route from Tulerosa to Apache. Many of the smaller streams now flowing will run dry later in the season. At 3 p. m. a party arrives from Apache with provisions, and, Lieut. Tillman reports, bringing mail and other material—quite an event in our forest life.

August 30.—The trail from this point follows nearly a due west course for a few miles, then, turning toward the north, comes out near the head of the cañon from the south that was noted as in full view to the east of south from the hill ascending near Green Corn Camp, the scene being at once grand and striking.

Making a steep descent, we commence the zig-zagging process along the mesa that faces the east fork, and emerge into the narrow valley of the stream directly opposite Green Corn Camp. Apache is soon reached, along the south bank of the stream. (For area visited, see northeast corner of atlas sheet 83 and southeast corner of sheet 76.)

The Indian tribes encountered were the Navajoes, Zuñis, Moquis, Jemez, White Mountain Apaches, and those found at Fort Bayard and Old Fort Tulerosa, also the following pueblos: Moquis, with its seven villages; Zuñi, including the outposts at Nutria, Pescado, and Ojo Caliente; Acoma, Isleta, Jemez, Tesuque, San Yldefonso, Silla (or Zia), and Laguna. The area under survey has embraced the greater part of that originally inhabited by the pueblo or town people and all of that belonging to the present pueblos, to all of whom grants of land have been or are in process of being confirmed.

The count, as stated at the agency of the Navajoes at Old Fort Defiance on the then last annuity day, was 8,616, which had, however, before reached as high as 9,700. In annual report of Indian Office for 1886 the enrolled number is given at 17,358. Not more than 4,000 to 4,500 were in the habit of appearing on annuity day. The agency is situated (1873) near the southern end of the reservation, while the several bands live along the banks of the San Juan and its southern tributaries.

They appeared to care little or nothing for their agent, and were kept in awe solely by the presence of troops at Fort Wingate, near southern extremity of reservation limits.

They had been moved a number of years before from the Pecos Valley. Many bands have large herds (reaching into the thousands) of horses, cattle, goats, sheep, mules, and donkeys. Manuelito, a fine specimen of an Indian, was their war chief, in fact the only one who had a voice with and a control over the whole tribe, the head chief being old, decrepid, and in his dotage. He had five wives or squaws, and each of the bucks of fine prowess and large wealth in stock had more than one. These dusky virgins possess a market value at maturity, the price depending upon family caste, good looks, chastity entering with considerable weight. The daughter of a prominent sub-chief is generally worth about four horses and twenty sheep, that are divided usually between the father, elder brother, and herself. As a race they are of more than average Indian intelligence, possessing rare qualities of shrewdness and cunning. Their facial dimension approaches the rectangular, and, except in individual cases, the high cheek-bones and irregular noses are lacking. The squaws are better treated than in any tribe yet visited (1873), and, although obliged to do some of the drudgeries of manual labor, still spend considerable time at their weaving and produce a woolen textile fabric for use as garments and for household purposes. This tissue is excelled by none for durability and unrivaled because of its impermeability. Tradition dates their knowledge of this art (back of any historical association, however) to a Welsh or Danish woman, who lived to a good old age among them, and they now worship an old woman as one of their deities. In early days they colored their raw weaving material in natural dyes, black, green, and yellow, but since the Government furnishes them colors, they have discarded their own for an inferior substitute. Some of their designs are highly characteristic and show good taste for color and figure. Should one Indian kill another by accident, another life must be the ransom or the payment of a stipulated number of horses or sheep, or a certain sum of money. Their sense of retributive justice is strong. Three or four Navajo pupils were being educated at the agency at a cost of $1,200 per year to the Government. The Navajoes had for a number of years made regular raids on the Mormon stock herds to the north of the Colorado, which has latterly, however, been stopped. They fear the incursion of the pale-face, but above all dread an inroad by the Chinese, that, locust-like, would consume everything in the land.

The ranches were few and far between along the route, and taking into account the extent of the Navajoe and White Mountain Reservation and the ground claimed by the Zuñis, there was but little land left to encourage the settler to wander in this direction. However, the area visited to the east of a north and south line passing through the highest point of the Sierra Blanca and embracing thousands of square miles cannot be excelled by a like area on the continent for grazing and timber, while certain of the glades and valleys below 8,000 feet in elevation are susceptible of tillage, and the dark volcanic soil (of trachytic and basaltic components) is unsurpassed in natural fertility. The points at which floatrock even of the precious minerals had been found were few. Prospectors showed, besides the precious stones, specimens of silver ore, reputed as coming from the Navajoe Reservation, still others from the Zuñi Mountains, while a third spot on the banks of Salt River, south and east of Apache, had been prospected successfully and locations made by Mr. Cooley, a guide and interpreter at Apache. Other mines of copper and silver ore had been discovered on the San Francisco branch of the Gila.

The only general wagon-route through the area visited personally was the one leading from Wingate to Apache, while now a railroad (the Atlantic and Pacific) from Albuquerque, on the Rio Grande, to the Needles, on the Colorado, has been built and opened (1883), and the Arizona portion of the region visited in 1873 is reached from a station named Holbrook, on the

Little Colorado, from whence stages depart for Apache direct, and for Springerville (Milligan's Ranch) via Saint John's, on the Colorado Chiquito.

The only lakes reported in the Arizona and New Mexico portions of the area are two small ones (more properly lakelets or ponds), the first lying near head of White Mountain River, and the second found near the head of another branch of the North Fork, both small reservoirs emptying into the stream in question, and a third (Reservoir Lake) lying near the headwaters of Salt River, and without visible outlet. This lake lies in a shallow basin, its waters resting upon and walled in by lava, slightly eroded. The water is shallow, weeds reaching the surface. At its stage in August it covered approximately 50 acres, with a possible 75 acres at maximum. An old beach, 10 feet above present level, long since abandoned, is observed. It appears to be permanent on account of the life it contains, and must have an underground outlet, as its waters are fresh. From the summit of the Sierra Blanca, as one looks eastward at the rising of the sun, and when the adjacent amphitheater is first flooded with its morning light, it sparkles like a jewel, and is well set off by its mountain and mesa surroundings, by which it is encircled on every side. The sources of the streams making up the headwaters of the forks of White River, the Salt, Bonito Prieto, Blue, San Francisco, Gila, and Little Colorado Rivers, are perpetual springs, rising near the mountain summits from storage reservoirs in the trachyte, dolerite, and basalt of this region, and following the courses that lead to their far-distant ocean level in the Gulf of California, they soon expand into a number of sparkling streams within the lava region which traverse a plateau-like area in which the cones of the Sierra Blanca are centrally situated, the picturesqueness of which is not equaled within our borders, not forgetting even the Willamette Valley of Oregon, although the latter, long and level, affords wider fields for agriculture, while much of the Eastern Arizona and Western New Mexico region, in which the Sierra Blanca lie centrally disposed, is valuable only for grazing and timber, water being in abundance; a country indeed in striking contrast to the comparative deserts of the lower Colorado Chiquito, Gila, and mesas westward of the Rio Grande in like latitudes.

These streams, particularly mentioned and belonging to the portion visited, all finally reach the sea by the mouth of the Colorado of the West, the continental divide lying to the eastward.

The portion known as Mogollon Mesa and White Mountain Region consists, geologically, the former of Carboniferous strata (limestone predominating) and volcanic material, in the following order of sequence, as observed by Mr. Gilbert: (1) Trachyte; (2) *Sanidin-dolerite; (3) Basalt. In the Geological Maps, Nos. 1 and 2 are designated as trachyte and rhyolite. This volcanic field is an arm of a great region of igneous rocks, reaching almost continuously from San Francisco Mountains, on the northwest, to Mount Taylor, at the southeast, as centers of flow, and estimated as covering about 25,000 square miles. It lies principally between latitudes 32° 45′ and 34° 20′, and longitudes 107° 30′ to 110° west of Greenwich. Thomas Peak, the summit of the Sierra Blanca, is also an elevated center of disturbance, and the resultant eruption and uplift has left lava beds of about 3,000 feet in thickness lying presumably on the Carboniferous, which is observed to the eastward of Camp Apache, along Main or East Fork of White Mountain Creek for 8 or 9 miles, there passing under the volcanic cap.

Mr. Gilbert assumes three distinct lava flows in the order above given, the trachytic being the least recent. The basalt appears in patches, except to the north of the Sierra Blanca, Green's Peak being a center of an extended basalt area, which also appears along the bed of North Fork to vicinity of Fort Apache, the latter showing Carboniferous.

The Little Colorado, near its head, is covered with almost continuous patches of basalt, the Triassic emerging near the present site of Saint John, and continuing along the valley to Sunset Crossing, where a Carboniferous horizon appears. Triassic also obtains in vicinity of Fort Wingate; the Zuñi Mountains are Carboniferous, while the Carrizo Valley and Zuñi Plateau show cretaceous sandstone as predominating. The approximate zones (limited by altitudes) of the class of botanical products in the 1873 region in New Mexico and Arizona have been given by Dr. Loew (see p. 603, Vol. III), as four, viz:

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* The term "sanidin-dolerite" was proposed by Mr. Gilbert for temporary use. See p. 526, Vol. III, Geology.

(1) Zone of cactus, yucca, and agave; altitude 3,000 to 3,500 feet; grass scanty. Where there is water a most luxuriant vegetation springs up.

(2) Zone of *Obine* and *Artemisia* (greasewood and sagebrush); altitude 3,500 to 4,900 feet; grass poor, with few exceptions, on granite and volcanic soils. The cactus species are diminished in numbers.

(3) Zone of *Juniperus occidentalis* (cedar); altitude 4,900 to 6,800 feet; cactus species few.

(4) Zone of pine and fir, 6,800 to 10,800 feet (highest points).

Thus are presented, between latitudes 33° and 34° north, and at elevations from 3,000 to 11,000 feet, plant life comparable with that of the Sahara Desert, warm, temperate, and subalpine climates. Dr. Loew also presents in Volume III highly interesting results of soil and mineral analyses and of mineral springs, among which may be noted the comparison of the mud of the Rio Grande with that of the Nile, in which it is found that the former is richest in potassa and the latter in phosphoric acid, the deduction being drawn that no other or better fertilizer is required than the layer of finely-pulverized virgin soil that results from irrigation in the middle Rio Grande Valley.

Of the collections of fish, many coming from the streams heading in and near the Sierra Blanca, there were sixteen new species. Mr. Henshaw adds to the list of birds, and determines the presence of several well-pronounced Mexican types. Dr. Rothrock adds his chapter and data to the critical and economic botany of this section (see Volume VI).

The predominating timber species observed in the White Mountains are the pine (*Pinus ponderosa, Pseudotsuga Douglasii*), fir and spruce (*Abies concolor* and *Picea Engelmanni*), oak (*Quercus undulata* and *Emoryi*), black walnut (*Juglans Californica*), and juniper (*Juniperus Californica*). During the seasons of 1873-'74-'75 a number of objects of archæological interest were obtained in New Mexico and Arizona, to which reference is made in Volume VII, p. 374 (see also Plates XVI, XXVII, and VIII, Volume VII).

These articles were but individually collected in an irregular and desultory manner, pointing, however, to the localities whence is likely to come, through systematic search, a clearer view of the circumstances of life of the pre-aboriginals and to the regions where the sites of ruins are counted in great numbers, a part of which area yet awaits thorough exploration, and within which the surface of the subject of archæology has been as yet but scratched.

Twenty-seven hundred geological specimens were collected during the season, also 4,500 fossils and 1,600 minerals, ores, &c., together with those mentioned in the following list:

COLLECTIONS.

The following summary shows the number of specimens collected during the season:

Mammals, comprising alcoholics, skins, and crania, 67.

Birds, comprising alcoholics, skins, crania, sternæ, nests, and eggs, 1,450.

Fishes, comprising alcoholics and skins, 1,660.

Reptiles, alcoholics, 280.

Insects—Orthoptera (grasshoppers), 105 lots, probably 2,500 to 3,000; Coleoptera (beetles), 60 lots, probably 2,000 to 3,000; Lepidoptera (butterflies), including Zygenidæ and Bombycidæ, 428; Hymenoptera (wasps and bees), 90 lots, probably 4,500; Diptera (flies), 17 lots, probably 170; Hemiptera (bugs), 67 lots, probably 1,500; Neuroptera (dragon-flies), 41 lots, probably 200; Formica (ants), 30 lots, probably 2,000; Arachnidæ (spiders), 54 lots, probably 600.

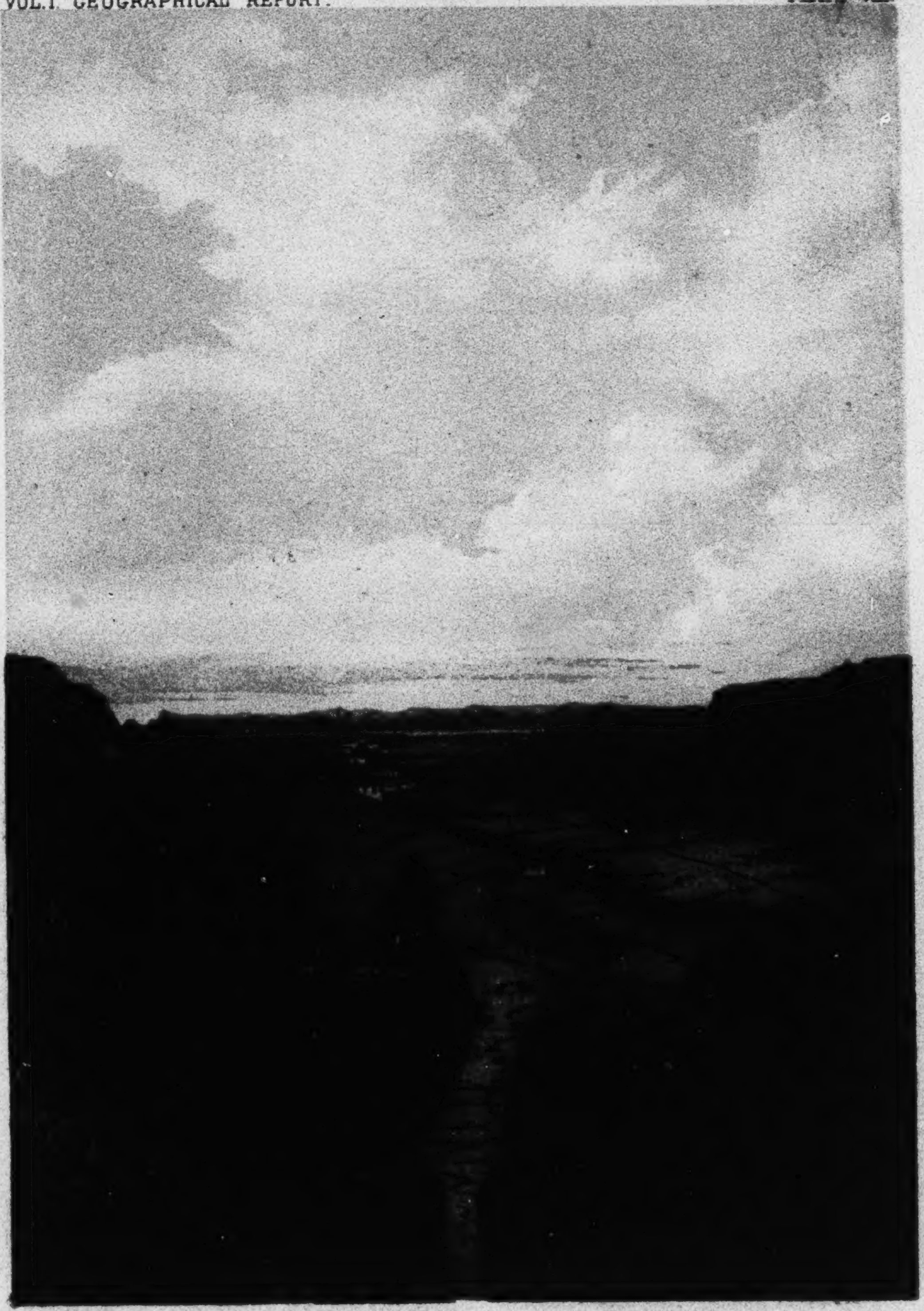
Mollusca (shells), 22 lots, probably 500.

Worms, leeches, and crustacea, 52 lots, probably 600.

Also 19 lots ethnological specimens.

These have since been transferred to the National Museum.

Plate VIII.—This view, sketched by Mr. Gilbert Thompson in 1873, from Echo Peak, opposite the mouth of the Paria, marks substantially the commencement of the main or lower Grand Cañon of the Colorado River, or the one ascended to the mouth of Diamond Creek by the boat party of 1871. An edge of the Paria Plateau is shown at the right, and the eastern escarpment of the Buckskin Plateau appears at a distance in the center. The cañon, passing centrally through the view, here presents the appearance of having been forced asunder as if by the upward pressure of a widely extended and rapidly applied subterranean force, whereas observation goes far to prove that the volume between its mesa-like walls has been removed in greater part, if not all, by the slow process of water erosion, assisted somewhat by the denuding effects of the atmosphere. So far as known, the cañon nowhere presents so even and unbroken a surface at the summit of its first walls, that are usually quartzite resting on granite, the beds that constitute here the exterior and outlying plateau approaching much nearer the bed of the stream from its entrance into the deeper cañon, commencing at the Buckskin Plateau, only to terminate at the Colorado crossing of 1871 (see Atlas sheet 66), a distance of approximately 280 miles.



CROSSING OF THE COLORADO RIVER NEAR MOUTH OF PARIA CREEK.

(EASTERN EDGE OF THE GRAND CAÑON IN THE DISTANCE.)

1873.

ABORIGINAL LIFE IN THE NAVAJO COUNTRY NEAR OLD FORT DEFIANCE, ARIZ.
1873.)

SANDSTONE WALLS IN CAÑON DE CHELLE, N. M.
(CAMP BEAUTY 1873.)

The variegated and vivid colors of the mesa walls of the above plateau as seen from Echo Peak (from which point a pistol-shot gives seven distinct reverberations) present a beautiful appearance.

Plate IX.—This sketch, in colors, is from a photograph by O'Sullivan, taken at one of the Navajoe wick-e-ups, near Old Fort Defiance, and is a scene of Indian every-day life. The head and lord of the family looks on with phlegmatic equanimity at the patient industry of the squaw and indulges in day dreams, undoubtedly of victories of war or excitement of the chase, performed by him or his ancestors. They gather a scant harvest of corn and grain, but depend now for the greater part upon Government rations.

The slow process of weaving the famous Navajoe blankets may thus be described: Two horizontal poles, at a little greater distance apart than the length of the blanket, are fastened to two substantial uprights, while a third horizontal pole (movable) receives the stretched warp threads at a convenient distance from the ground; the woof threads are inserted, one by one, by hand, each being followed up by a narrow, thin-edged board, hammered down by a cleat so skillfully handled as to scarcely break a thread. The time for completing a full-sized blanket varies from two and a half to three and a half months, according to fineness and design. Aboriginal, Government, and imported yarns are used. These blankets, often of excellent design, are unique as regards warmth, durability, and impermeability.

Plate X.—The walls, shown in the picture, which is a reproduction from a photograph by the late T. H. O'Sullivan, in 1873, at Camp Beauty, in the Cañon de Chelle, were estimated by him to be 1,200 feet in height. Mr. Victor Mindeleff, of the Geological Survey, gives them at 1,000 in 1885. The abrupt descent into this cañon is reached from the south by a trail from Old Fort Defiance (35 miles distant), traversing a dry, sandy desert plateau.

The main of the shafts of rock at the right (all solid sandstone, of obelisk shape) is stated to be 742 feet high. These stand in an isolated group near the center of the cañon.

The same columnar form is represented elsewhere in the valley of the Chelle (which in places is 3 miles wide) by the "Explorer's Column," a pillar in altitude equal to the above of regular, shaft-like form. At this point five lateral cañons converge from as many directions toward the main gorge, giving the locality the appearance of a star of six points. The walls are substantially vertical near the mouth of the cañon; the bottom is sandy and flat.

The stream which rises near the head sinks beneath the sandy floor before reaching this point. The débris from the less vertical walls accumulates nearer the source, while the cañon gorges, towards its head, entirely disappear.

The ruins of the Cañon de Chelle were first brought to notice through Lieutenant Simpson's reconnaissance of 1849. Some are said to be 400 feet above the river bed, and without evidence as to how they were reached. The Navajoes have no knowledge of their origin, or a tradition, even, and apparently they have been long in ruins.

One of the ruins of the Cañon de Chelle (represented in Plate XX, Volume VII, Archæology) is shown to be 50 feet above the cañon bed, and was named "Casa Blanca," or "White House."

Beneath it are ruins of other stone structures, the former appearing to have been a fortress or place of refuge in time of danger.

The walls are made of soft stone, split but not dressed, held together with mud mortar and covered on the outside with a whitewash or plaster of unknown composition.

The wall-rocks, of a somber red sandstone, blending into a rich brown, approaching to black in places, are slightly furrowed nearly horizontally by the storms driving through the cañon, and vertically by the dripping from above. These ruins, in the main, appear to have been located conveniently to the tillable areas, while some of the largest are constructed upon the bed and at the sides of the cañon, with others above them. These latter are true cliff-dwellings, the niches or alcoves in which they have been built receding scarcely more than 10 feet, and are in no sense caves. The approximate length of the cañon is 30 miles.

Plate XI.—This view (in colors) is introduced to illustrate, although but rudely, the beauty of the park-like valleys found almost indiscriminately along the flanks of the Sierra Blanca Range of Eastern Arizona. It is a reproduction from the only typical scene photographed by the late Mr. T. H. O'Sullivan. No picture can equal the original and no pen nor language describe the rugged grandeur of the broken surrounding mesa and mountain or the gentle valley-like glade, finely grassed and interspersed with pine groves. The soil of the valley portion responds to the husbandman at this altitude (less than 7,000 feet), while the surrounding rolling hills, as well as the mesa tops and the foot-hills, where the timber is not too dense, are covered with the richest growth of the nutritious grama and bunch grasses, making it one of the most desirable of all stock ranches. The coloring is by the hand of Mr. H. J. Morgan, following sketches and notes taken in the field.

Plate XII (Alpine Lakes, Cerro Blanco Mountains).—East of the Continental Divide, at the head of the Arkansas, which from this point follows the crest of the Saguache arm of the Sierra Madre and as far south, approximately, as Santa Fe, N. Mex., lying between the valleys of the Rio Grande and the Arkansas, and in which head the Purgatory, Cimarron, Canadian, Moro, and Pecos Rivers, as well as many minor streams of the Rio Grande and Arkansas basins, is found a succession of mountain ridges fronting the great plains in bold relief along a line not far differing from the meridian of Pike's Peak. The Sangre de Cristo Range, although a little to the westward, mark, with the Wet Mountain Range, immediately to the east, the northern limit of the Vera Mountains and Cerro Blanco group (sometimes called Sierra Blanca), apparently gathering the two above ranges into one, the Culebra, with the prominent Spanish Peaks, as eastern sentinels, which latter, a narrow ridge, in turn widens out until farther to the southward appear the Cimarron, Taos, Mora, Las Vegas, and Santa Fe ranges (see Atlas, sheets 61 B, 61 D, 62 A, 62 C, 69 B, 69 D, 70 A, and 70 C).

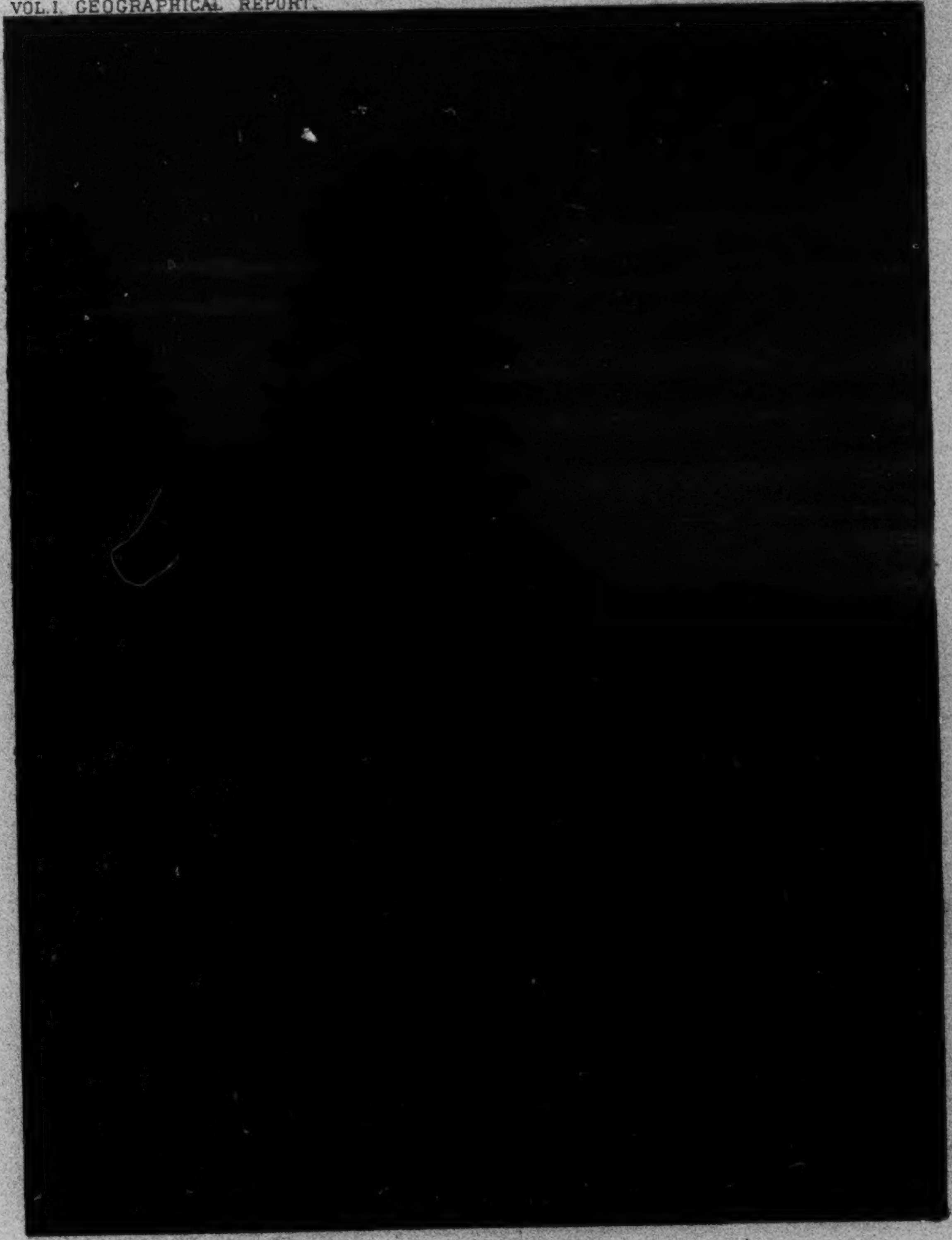
The subject of the accompanying illustration, embracing the summit of the Cerro Blanco, occupies a salient in the great San Luis plain or valley north and west from Fort Garland and quite separated from the main ridge, forming the nucleus of a special group, although in continuation of the general trend of the Sangre de Cristo.

The peak lies in latitude 37° 34′ 43″.5 north, and longitude 105° 28′ 53″.3 west of Greenwich, and at an altitude of 14,270 feet above sea, the mountain group forming the divide between the drainage basins of the Upper Rio Grande and Huerfano, a small tributary of the Arkansas.

U.S. GEOGRAPHICAL SURVEYS WEST OF 100TH MERIDIAN.

VOL. I. GEOGRAPHICAL REPORT.

PLATE XI.



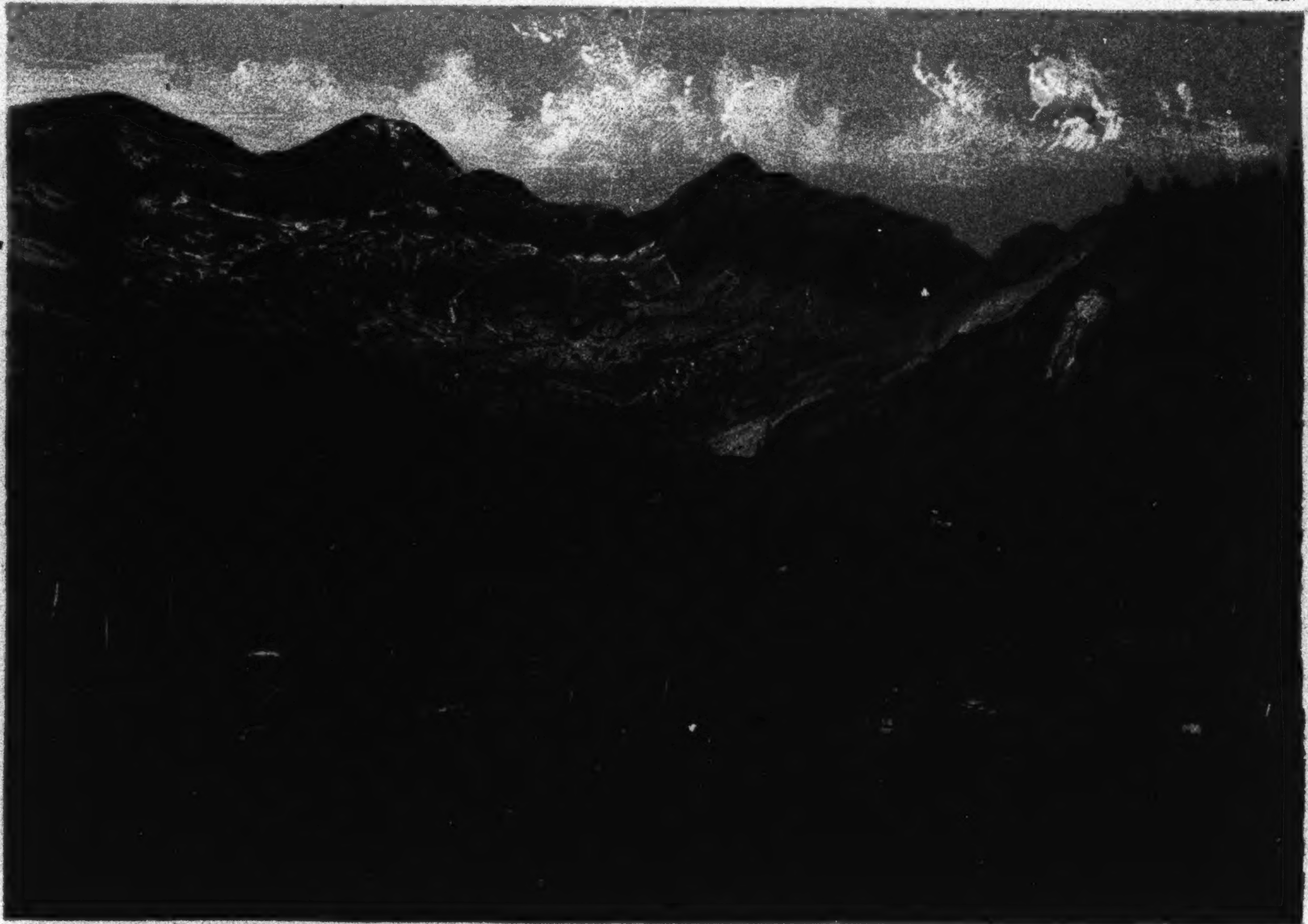
COOLEY'S PARK, SIERRA BLANCA RANGE NEAR CAMP APACHE, ARIZONA.

1873.

U. S. GEOGRAPHICAL SURVEYS WEST OF 100TH MERIDIAN.

VOL. I. GEOGRAPHICAL REPORT

PLATE XII.



ALPINE LAKE, SUMMIT OF CERRO BLANCO NEAR FORT GARLAND, COLO.

1874.

Four well-known passes lead from the valley of the Arkansas to the San Luis, in vicinity of this mountain mass; to the north the Mosca (9,787 feet), to the east the Sangre de Cristo (9,578 feet), and leading into it the Veta (9,392 feet), and a little more to the southward, but joining Sangre de Cristo Creek on the west, is Indian Creek Pass (9,720 feet). Since occupying this peak and region the Denver and Rio Grande Railroad have utilized the Veta Pass in its branch leading to the Rio Grande and the southern part of the San Juan region.

The ascent of this peak can only be accomplished from the main western branch of Placer Creek, that takes its rise near the eastern summit, which along a narrow northern spur is exceedingly precipitous until a small bench is reached, approximating 11,000 feet, at the immediate foot of the bare granite mass cut by many trachytic dikes of considerable size, of which the peak proper is composed. Here little Alpine lakes (like that shown in the view) act as reservoirs for the perpetually melting snow of the summit ravines. The timber line ceases where the lakes commence. Ten lakes were counted rising in terraces.

The most elevated are kept full and cool throughout the summer from the constant melting of the perennial snows along their edges, from where the overflow feeds those at the lower levels, until the lowest empties into the drainage of Placer Creek. So far as known, it had never been ascended by white man prior to August 14, 1874, when Gilbert Thompson and Frank De Y. Carpenter, topographers of the expedition, occupied it, as a main triangulation station, remaining over night on the summit. The top is but a few yards in extent and occupied almost entirely by a circular depression, possibly used by Indians as shelter for their sentinels, who probably occupied this at once commanding and strategic point as a watch-tower from whence to signal the approach of an invading force, especially from any direction in the broad expanse of the San Luis Valley.

The peak lying to the left of the center of the sketch is the one to which reference has been made. The crayon lithograph plate was produced from a photograph by O'Sullivan, as an original.

Geologically (as determined by Prof. J. J. Stevenson and Mr. F. M. Endlich) this peak is a naked mass of eruptive granite (grayish in color, resembling syenite, and uniform in texture), which apparently terminates one of the anticlinals of the Sangre de Cristo Range. The granite is flanked at the southwest by trachytic beds.

EXPEDITION OF 1874.

The expedition of 1874 covered an aggregate area of 23,281 square miles, distributed as follows: Arizona, 275; Colorado, 3,600; New Mexico, 19,040; and Utah, 366 square miles, and found in the basins of the Rio Grande, Gunnison, Arkansas, Chama, Cimarron, Mora, and Canadian rivers.

The main parties were organized at and operated out from Pueblo.

NOTE.—The general route followed by the officer in charge was from Pueblo to Fort Garland, via Sangre de Cristo Pass, thence to Conejos, thence via Prospect Peak, heads of Conejos and east fork of San Juan to Pagosa Springs, thence to Tierra Amarilla and return, thence via head of San Juan and south fork of Rio Grande to Del Norte, thence by stage to railroad at Cañon City, Colo.

The topographic results of this season are to be found in Atlas Sheets 61 C, 61 D, 62 C, 70 A, 70 C, 69 B, 69 D, 69 and 68.

The routes of early explorers traversing a part of the area are: (1) Pike, 1807 (to the Rio Grande); (2) Frémont, 1844; (3) Simpson, to Cañon de Chelle, 1849; (4) Gunnison, and (5) Whipple, P. R. R. S., in 1853, and (6) Macomb, 1859.

The subdivision of the public land surveys had been carried on only to a limited extent, except in vicinity of Pueblo, Trinidad, Fort Union, Las Vegas, and Santa Fe; nor, indeed, except in the San Juan regions, have later calls (1883) demanded the sectionizing of these lands to any considerable extent.

PARTIAL ITINERARY, 1874.

From camp on Smith's Island, near Fort Garland, to Tierra Amarilla, via heads of Conejos Creek, San Juan River, and Pagosa Springs.

August 17.—Broke camp and moved westward a distance across San Luis Valley of 16.8 miles, and camped upon the Trinchera, a tributary of the Rio Grande, about 4 miles from the mother stream. The road descends gently for the entire distance, is sandy in places, and finally enters the bottom of the creek at a bend shortly below the junction of the Ute and Sangre de Cristo creeks with the Trinchera.

In the horizon are the broken ridges composing the Sangre de Cristo Pass, due east of the Cerro Blanco peaks, and farther to the north the Sangre de Cristo Range; the Saguache (southern ridge of the Sierra Madre) and the mountains at the head of the San Juan to the northwest, and their southern spurs immediately to the west of camp, while in the southern horizon volcanic masses join these foot-hills and several flat-topped mesas on either side of the Rio Grande.

August 18.—A camp near the little town of Conejos is reached at a distance of about 20 miles over a comparatively level road, the river admitting of being forded at this season. Observed nothing worthy of note, except the so-called Hot Springs at Norman's Ranch, near Conejos Creek. The main spring flows 8,000 gallons per minute, varying in temperature from 53° to 65° F. Several smaller ones appear in the vicinity. These springs have long been used by the Mexicans for rheumatic affections. This group of springs occurs 20 miles east of where the foot-hills of the San Juan Mountains reach the plains. Here and there appear island growths of the black species of grama, while the artemisia is persistent. The strip of land north of the road from the ford to Conejos and east of the foot-hills and northward to Del Norte could all be brought to a high state of cultivation to the extent of the volume of water of the Rio Grande and the mountain creeks flowing to the eastward.*

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* NOTE.—Guadaloupe, the oldest plaza, was located November 24, 1854, the others more recently. Most of the inhabitants came from New Mexico. The church in Conejos was erected in 1858. Over 1,000 persons attend services each Sunday, but more than 2,000 pay tithing. A college and convent are in process of erection. Three priests and five monks constitute the head of the church in Conejos County.

August 24.—Lieutenant Whipple with the main party follows up Conejos Creek, with instructions to camp at a point convenient for a party under my direction engaged in a détour to the north and ascent of Prospect Peak. The détour route lay for a mile along the creek, with banks of about the same level as the plain which adjoins the low volcanic foot-hills that, bordering the Conejos and San Antonio Creeks, are of basalt in place on the Mesa and as finely comminuted drift at the lower levels. A sparse growth of scrub cedar, stunted pine, and spruce form patches on Prospect Peak, from which the view toward head of Conejos Creek was extremely beautiful, bearing resemblance to portions of the more broken ravines and mesas of the White Mountain regions pierced the year previous.

A little creek reaching the Conejos from the north is visible here and there, half valley, half glade (timbered along its flanks with pines of considerable size, interspersed with quaking aspen), until cut across by one of the southern forks of the Alamosa. The volcanic covering of the mesas, of the entire western horizon of Prospect Peak (densely wooded in places), much resemble on a small scale the basaltic lava field in the vicinity of the Sierra Blanca of Arizona.

One Mr. Wallace, a deputy mineral surveyor, reports a peg found and pulled up by him in the Sangre de Cristo Pass, about 3 miles below Stearn's Ranch, marked "Lt. Pike, 1807," which would indicate that this officer was marking points of his route, to be recognized by others in case of his loss or capture, the latter taking place at the junction of San Antonio creeks (where it is stated that the ruins of a block-house, built for defense of his party, still stands), and also that he passed from the basin of the Arkansas to that of the Rio Grande de Norte, by either the Sangre de Cristo or the Veta Pass. Color (gold) results from rude pan-washing in the bed of Conejos Creek.

August 26.—Three divisions are made, one going to Prospect Peak to augment observations, a second following the main valley of the Conejos, and a third (with the writer) to reach a rendezvous at a point named Red Bluff, via head of Prospect Creek.

On account of want of trail and serious physical obstacles the party did not rendezvous until the 28th at Beaver Dam Camp higher up the Conejos and nearer junction of its two main forks. Basaltic lava everywhere predominates, making box or impassable cañons along the main stream and certain tributaries. Deer and foxes prevalent as game, and fine mountain trout in the stream. Yellow pine, spruce, and aspen are abundant on every side, with rich mountain bunch grass in the ravines as well as upon the mesa slopes.

August 30.—No rocks underlying the basalt of this portion of Conejos Creek are noted, the specimens found in cañons to the westward and on Conejos Peak being all volcanic.

The Chama heads to the west of Beaver Dam Camp. Shortly after leaving this camp the Conejos turns to the westward, when highly metamorphosed granitic rocks appear. The character of the creek bottom changes, widening into a little park, spruce timber appearing on surrounding mesa-like hills except when the rock is exposed. Fox, martin, beaver, grouse, and duck were seen and captured in this locality. Soon the Conejos turns to the south and west, and its bed is left to cross a little divide which presumably would lead us on to the stream near its head (a camp being made in a wilderness of timber) near the divide and toward a stream the banks of which being reached was found to flow to the north and east. This proved to be the South Fork of the Alamosa.

August 31.—Visited mines near the South Fork of Alamosa Creek, believed to lie in the southern extension of Summit District. The formation is here a metamorphic granite, while the lodes prospected were noted in connection with quartzite, said to contain free gold, and affording high assays.

September 1.—Follow the Alamosa without trail to near its source, which is found to be from glacial snow-banks near Summit Peak.

September 2.—Summit Peak was climbed, its elevation proving by computation to be 13,393 feet above sea. Around the cluster of peaks in its vicinity heads the Alamosa, Conejos, and Blanca creeks, and the Chama River, and east fork of the San Juan and South Fork of Rio Grande. This mountain peak appears to be one mass of highly metamorphosed syenitic granite. While the geology of the foot-hills west of the San Luis Valley has proven simple, that of the uplifts, in which nestle the sources above named, is quite complex, and yet awaits full study.

The Conejos is entirely late volcanic to the point of its turning westward; then appears granite but little altered, then granite on the South Fork of the Alamosa highly metamorphosed, interspersed with dikes of quartzite and beds of conglomerate, along the route followed, while on the east fork of the San Juan older lavas much contorted are the surface formation.

Here one of the worst descents into the cañon of the East Fork of the San Juan ever made by our expedition pack-trains was undertaken, and camp made in a little nook overlooking an almost perpendicular cañon wall, fully 1,000 feet in height.

September 3.—A camp is finally made in a glade, lower down the stream, that flows due westward, which had to be forded several times at great risk at selected points. Here the parties separate, the one under my charge pushing ahead to reach finally a welcome trail, which proves to be the one leading from the Upper Rio Grande, at the mouth of its south fork, to Pagosa Springs, on the main San Juan, where a rendezvous camp was established, and from which point exploring and surveying parties were dispatched in all directions.

Pagosa to Tierra Amarilla and return.

This trip was made by the westerly route, crossing the mesa to the west of the Chama River at Horse Lake, returning by the route following toward head of Chama, then crossing the heads of Navajo and Blanca creeks, reaching the eastern banks of the San Juan.

Portions of this route had belonged to the old trail from Santa Fe to the Northwest, and was followed by the Escalante exploring party in 1776. This country is a succession of mesas, bordering on the Chama, Chaco, and San Juan Rivers, well described in the reports of Professor Cope. The country is well grassed and timbered, although scantily supplied with water, except along the several creeks. The Blanca, nearly dry, was the first stream crossed, then the Little, and a little farther on the main Navajo, reaching the Chama, opposite the Mexican settlement of Los Brazos, a few miles south of which was found the site of Old Fort Lowell.

The name Tierra Amarilla (yellow earth) is descriptive of the alluvial soil washed from the persistent sandstone mesas found on either hand.

The Denver and Rio Grande Railroad now has a junction at a station called Antonito, a short distance south and east of our camp at Conejos, from whence one track runs southward along the Rio Grande; a second, or the western branch, reaching the Chama by head of Los Pinos Creek, thence by one of the heads of Navajo Creek to the San Juan at its mouth, thence along the San Juan to mouth of the Piedra, thence partially across a mesa westward to Los Pinos Creek, thence to Durango, its terminus, in the valley of the Animas, from which a northern branch has been run to the mining town of Silverton. Thus the southern half of the intricate and comparatively inaccessible San Juan region is tapped and given a communication with the outer world; while the northern part is fed with a branch of this same railroad enterprise entering the valley of the Gunnison from the Arkansas via Marshall's Pass, following the former river to near its junction with the Grand, thence substantially on the old Gunnison wagon-road to Salt Lake City. The San Juan region, having Ouray as a center, feeds into this road at Montrose, approximately 45 miles from Ouray, while a branch of same road through the Poncho Pass reaches the town of Gunnison via the head of San Luis Valley and ridges to the westward, the road being tapped from Lake City at Sapenero Station, 38 miles distant. The Alamosa branch has been extended as far as Del Norte and branches from Gunnison and Poncho Pass pierce into the adjacent mining districts, forming further arms of this vigorous and useful narrow-guage system.

The route from Pagosa Springs to the Rio Grande at the mouth of its south fork lay along the banks of the San Juan to its main head, thence by a tortuous, almost blind trail at more than 10,000 feet altitude to the heads of the south fork of the Rio Grande, thence to its valley reaching a wagon-road at a saw-mill a few miles before attaining its junction with the main stream (altitude 8,016 feet).

A most beautiful little mountain valley is found on main fork of the San Juan two or three miles above junction of east fork, thence the trail ascends the high, bare, precipitous mountain ridges upon which it was necessary to camp when darkness came, at an approximate elevation of 10,500 feet amid snow, sleet, hail, rain, thunder and lightning, in the face of almost a hurricane of wind; these combined demonstrations of nature, playing each its separate tune, all discordant, which was not enhanced in melody by the cracking, crashing, and crunching of the tall gaunt pines which as victims lay along the lightning's course.

Snow covered the ground 4 inches in the morning. So far as known there has never before been recorded within one horizon at one time in different parts of the heavens, rain clouds, the moon visible in a clear sky, with thunder and lightning, hail, and snow, all recurrent within the hour.

The sources of the Rio Grande are found in the heart of the so-called San Juan region at an elevation exceeding 12,000 feet, in latitude approximately 37° 46′ north and longitude 107° 33′ west of Greenwich, flowing eastward until it reaches the San Luis Valley or plain, and thence runs nearly due south until El Paso (a point on the Mexican border) is reached, from whence it makes easting to its mouth in the Gulf of Mexico.

During its fall of more than 12,000 feet a number of the series of geological formations have been cut. Archæan (granites), Carboniferous, and Triassic (with beds of basalt and other eruptive rocks on either hand) are noted before reaching the San Luis Valley; then various forms of alluvium appear until the latitude of Conejos is reached, when the river cuts its way through extensive beds of basalt and trachyte (the former predominating), which continue to the approximate latitude of 36° 20′. Here beds of the Tertiary (Loup Fork and other marls) and afterwards Triassic are found, reaching further south than Santa Fe, beyond which point no geological data has been systematized through this office.

The material held in solution and suspension, more especially from the limestones, trachytes, and basalts above mentioned, as well as those cut by the mountain affluents on both sides, conjoin to produce a sediment which when precipitated upon the lower bottom lands of the Rio Grande leaves there a rich residue which is an excellent fertilizer.

The annual rainfall along the banks of the river varies from an average of 14.02 inches (Signal Service observation of nine years) to an approximate maximum at the source of 60 inches. Although the larger portion of the area of 1874, on account of its physical irregularities, broken and mountainous character and dearth of rainfall (usually in the valley not exceeding 12 to 14 inches) and limited opportunities for irrigation is unproductive, still narrow strips along streams at levels not exceeding 7,000 feet can in nearly every case be cultivated by ordinary ditch irrigation, while the greater part of the grazing lands are found between 7,000 and 10,000 feet, with timber fringes at from 7,000 to 8,000 feet, at which point the forests found to exist set in, the latter reaching a limit at approximately 11,000 feet, above which bare and precipitous rock or débris constitute the mountain escarpment.

The character of the rock as to its susceptibility to surface or atmospheric denudation has a marked influence in determining the altitude limit of vegetation in a given latitude, as well as the position of the point itself with regard to humid-laden ocean currents, and therefore all observations so far made on this point fail to determine the actual limit that might be reached at any given latitude.

The valley of the Arkansas (approximately 2½ miles wide) is well covered with fine vegetation wherever water can be brought upon it. The valleys at the east flanks of Greenhorn Range (at elevation of 5,000 to 6,000 feet) are well grassed, but frosts occur throughout the year, except, perhaps, from June 1 to September 15.

The San Luis Valley is approximately 140 miles in length, and from 50 to 60 in width. A considerable amount of its territory could be brought under cultivation by husbanding the waters of the Rio Grande and all minor streams reaching it from every hand. The valleys of the Culebra, Costilla, Taos, Alamosa, and other creeks are all fertile and partially utilized, while the Rio Grande is dotted with settlements from where it emerges from the mountains at Del Norte to the Mexican border even, and in an increasing degree from thence to the Gulf.

The summits of the San Juan, Del Norte, Banded, and Chama mountains form a part of the great continental divide.

The southern portion of the San Juan area toward the Chaco and lower San Juan borders on a waterless region, given up to the last stage of a secular dessication that relentlessly claims it as a part of the desert land.

Legendary information exists among the Mexicans of running streams and springs that existed one hundred and fifty years ago that have now disappeared, while positive assertions are made of the drying-up of minor streams within the past fifteen to twenty years.

The famous Pagosa Springs and their surroundings, the scene of a rendezvous, were found in a virgin state, a sole squatter having improvised a log cabin, where afterward Fort Lewis was temporarily located, but, like many another of the pioneer military camps, moved farther into the wilderness.

The formation immediately around the springs is sandstone of the Lower Cretaceous, overlaid by a dark shale, exposed under which in places is a dark argillaceous, fossiliferous limestone.

These springs are at the end of a beautiful park, extending northward along the San Juan for miles. That it was a place of resort since ancient times by aboriginals is attested by deeply worn trails converging from all directions.

Hills rise about them several hundred feet, covered with dense pine, the San Juan Range appearing in the distance.

The various springs now active cover an area of fully 30 acres, the river having cut through an old bed of incrustations fully 12 feet thick. They are surrounded by a plain of limited extent richly covered with mountain bunch-grass. The large spring is about 30 by 40 feet, the water coming within 3 feet of the surface. Sounding was of no avail on account of the craggy character of the incrusted walls. No bottom was found at from 50 to 60 feet. The main or Mammoth Spring is intermittent, with subterranean outlet to the river, as well as another, but partly covered, exceeding a foot in width and 4 feet deep.

The rocks near the underground orifices are everywhere covered with sulphur, while at the mouth of the main outlet they are incrusted with a white porcelain-like substance with a calcareous base. Professor Stevenson thinks that the deep source is from the metamorphic rocks, and that sulphureted hydrogen is generated in the limestones of the Triassic and the Carboniferous.

An elegant natural bath had been formed (1874) by walling out the bulk of the San Juan and improvising a reservoir of proper depth, in which the hot and cold waters could permanently mingle, there resulting a scale of temperatures from about 70° to 140° Fahrenheit, according to position as regards mouth of main stream from the Mammoth Spring.

These springs are destined some day to be the site of a famous watering place. The principal constituent is sulphate of sodium. (See p. 627, Volume III.)

Temperatures 140°, 141° and 142° Fahrenheit were observed near the edge of the large spring; the temperature of the interior, however, could not be accurately ascertained for want of self-registering thermometers.

Besides Pagosa, the thermal and mineral springs at Manitou, Las Vegas, Jemez, and Abiquiu were visited, description and analysis of which appear in Volume III.

Professor Cope discovered large fossiliferous beds of extinct vertebrates, of which not less than 29 have been determined to be new, as shown in Part II of Volume IV.

The nomadic Indians encountered by the main body of the expedition were the Uncompahgre Utes, a branch of the great Ute family having Ouray (since dead) as their chief (also noted in 1873), with an agency near the town just being organized (1874) of the same name, also the Muache, Capote, and Weenemuche, or Southern Utes, and Jicarilla Apaches at Tierra Amarilla. The former Indians, since made more generally known on account of the White River massacre, in which a distant band of the same tribe took a part, have been massed further west and north, and their lower reservation thrown open to settlement under certain conditions. This appears likely to be the fate of all the reservations that were laid out originally as to size, with less regard to the want of the tribes than were many of the earlier grants of the Spaniards in our present territory of Arizona and New Mexico.

The following pueblos were visited by members of the expedition: Taos, San Juan, Nambe, San Felipe, Santa Aña, Sandia, Cochiti, Santa Clara, and Santo Domingo. (See Annual Report 1875, Volume VII, and special chapter on Indians.)

The natural resources of the country traversed are comparatively good. In the San Luis and San Juan valleys and the numerous cañons leading to them, and also upon the mesa land adjacent, grass is abundant, and water usually accessible and in many places plentiful for grazing purposes. Considerable portions of the plains along the streams can be readily irrigated, and, where used for farming, good crops are raised. The mountains yield abundance of timber, and in the side valleys leading into the San Luis Valley white pine of large growth forms extensive parks which will prove of great value to the future settler, if sufficiently protected. Large herds of cattle and flocks of sheep were found grazing in several localities, and several Mexican towns and ranches, besides those strictly in the mining regions, were encountered along the principal streams as far west as the Chama Basin.

Although the winters are long, the climate is mild, and grazing continues during the snowy season below the mountains. In the San Luis Valley timothy grass and clover have been introduced, and produce well where irrigated, and in some instances were found accompanied by the improved agricultural machinery prevalent in the East. But for the restrictions of Mexican grants of land, some of which are of disputed validity, the southern and southwestern portions of Colorado and northern portions of New Mexico would speedily entice a considerable population of farmers and stock-raisers.

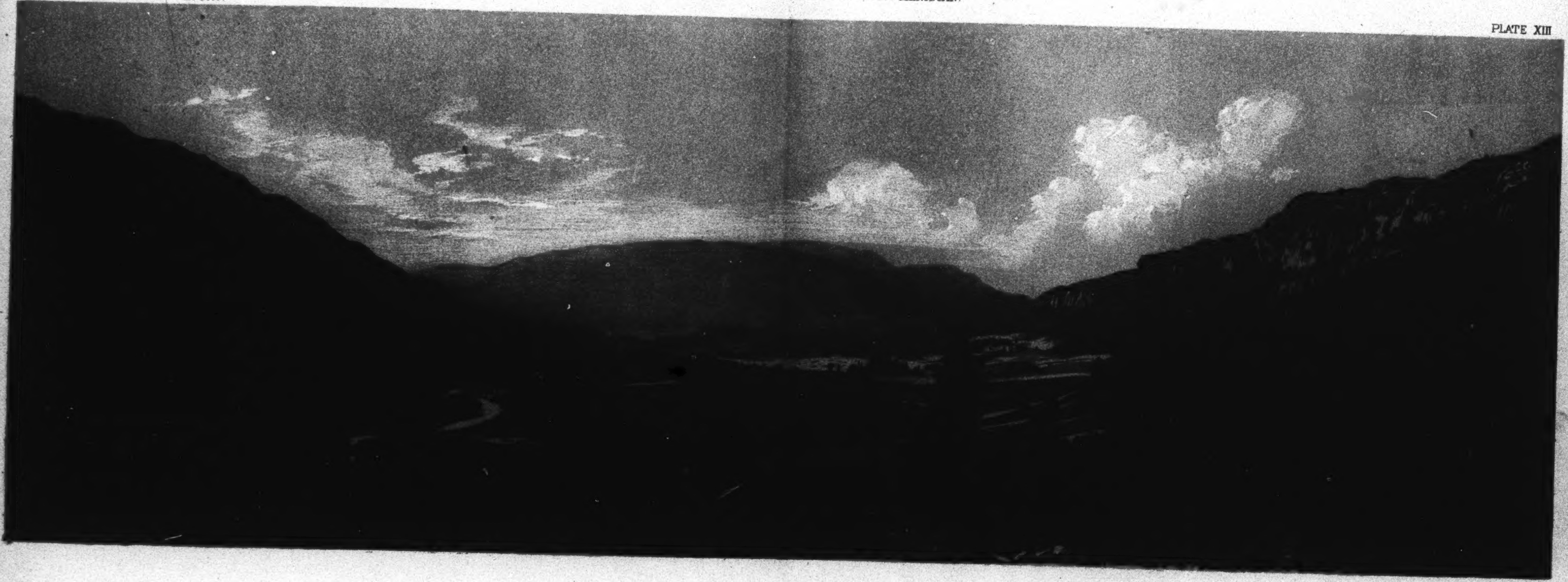
The region embraced is eminently a pastoral and timber country. Opportunity for agriculture is found only at specified points and over restricted areas. However the popular theory of the sterility of many a western mountain section has been exploded by actual examination, and the average arable lands below which the entire area west of the one hundredth meridian would not fall (the parties of this expedition having operated in portions the aridity of which is a maximum) is to some extent understood by a reference to the land classification tables in a later chapter.

Forests of yellow pine await the call for lumber and for mining timbers, railroad ties, &c., while spruce and fir, adjuncts to the forest, will help to swell the product. The climate at elevations not exceeding 7,000 feet is equable during spring, summer, and autumn, with heavy winter snows and well marked seasons for summer and winter, the spring and fall being variable. Those of the San Luis Valley and of the Upper San Juan and Chama are regarded as some of the best plateau mountain climates in the entire Southwest.

Stock raising had entered but little (1874) into these regions, that have since, however, been appropriated, and the San Juan Valley begins to bring a reward to the hardy settlers (other than miners) who have cast their lot in these far distant regions. This year's expedition but skirted the extensive San Juan mineral area, the knowledge of which is becoming greater each year and which must remain for a long period an important mining center.

The principal streams within the area, the San Juan, Rio Grande, and Chama (west of the San Luis Valley), all are blessed with numerous tributaries, especially the first; many of them were meandered and made known for the first time, adding thus largely to the critical data necessary to the complete understanding in detail of the topography of this intricate region. Springs and streams in abundance are found near the heads of the main streams. All the physical conditions of the vicinity of the numerous heads

PLATE XIII



BEAVER PARK VALLEY OF CONEJOS RIVER, COLORADO.

LOST LAKES, HEAD OF CONEJOS RIVER, COLORADO, GLACIER PEAK IN THE DISTANCE.

of these streams are notably different from the valley basins more distant from the sources, where the volcanic covering is wanting, and the valleys have been largely cut out of sandstone or highly arenaceous rocks. The rainfall in much of the area of the year exceeds 30 inches, while that deeper in the heart of the San Juan region reaches as high as 50 inches. Most of the volcanic and granitic soils retain moisture well, and hence the rolling valley grounds where dense timber is absent are perennially clothed with rich nutritious mountain grasses.

BEAVER PARK VALLEY—CONEJOS CAÑON.

Plate XIII.—This charming scene is laid near the head of Conejos Creek, not far from where it turns abruptly to the west and opposite a small western tributary.

Conejos Peak lies to the rear, and, covered by the distant foot-hills, is shown in the center of the picture. The formation on either hand is volcanic (trachyte), much broken below the edge of the inclosing bluff. The whole region, from the mouth of Conejos Cañon to the head of the East Fork of the San Juan, was found floored with lavas, old and new, with an occasional emergence of granite and quartzite. The valley elevation is 8,730 feet above sea.

Fragmentary rocky knolls here and there break in upon the low perfectly smooth and grassy foot-hills, adjacent to the creek bottom, which has been transformed into a grassy meadow, with tangled shrub growth, by the action of the beaver in damming the waters. Pine and spruce adorn the higher foot-hills, as also the bluffs on either side, and the region generally. These aggregate a whole of consummate beauty, worthy of the pencil of the most gifted landscape artist.

The plate was reproduced by crayon lithograph from a photograph by O'Sullivan.

LOST LAKES.

Plate XIV.—These lakes, of which there are three, hid in their mountain setting, were first discovered by myself from the westward route selected, which took the party from the head of Conejos Creek, Colorado, across a divide to the South Fork of the Alamosa.

The plate is prepared from a photograph by the late T. H. O'Sullivan, and but further attests his skill and endurance as a landscape photographer in mountain work. As the picture shows, the mountain sides are densely covered with evergreen timber to the very water's edge; they would lie "lost" from sight, except from a very few bare points peculiarly situated, hence the name.

They are situated at an elevation of (approximate) 12,000 feet, in (approximate) latitude 37° 20', longitude 106° 40' west of Greenwich. The forest is composed principally of yellow pine, spruce, and fir.

The lakes belong to the drainage basin of the Conejos.

The volcanic covering of the surrounding region is trachytic.

Except in the high mountains large game is not plentiful in this region, while, however, the streams abound in fish.

Important contributions were this year made by Professor Cope and Dr. Loew, the former in paleontology and archæology and the latter in geology, mineralogy, and soil and water analysis.

Messrs. Yarrow, Rothrock, Henshaw, and Aiken added largely to collections heetofore made, and their reports are found in the Annuals and Volumes V and VI.

Of archæological interest may be mentioned the excavation of Indian graves at the burial-place of a ruined pueblo, found on a mesa fronting the Chama Valley, at foot of the Jemez Mountains and about 3 miles east of Abiquiu.

The town had been built in the shape of an L, with an open area or court, and the usual estuffa or council chamber. The bodies were found buried within 30 feet of the walls of the pueblo. One entire skeleton was secured (subsequently deposited in the Army Medical Museum, Washington, D. C.), and portions of several others, with a number of skulls.

Evidences were found of the ruins of six to eight pueblos in the Chama Valley, affording habitations sufficient for 2,000 to 3,000 souls, as estimated by Dr. Yarrow.

Ruins are scattered indiscriminately over an area somewhat as follows: Between 35° and 39° latitude and west of the one hundred and sixth meridian, to the junction of the Main and Little Colorado, with isolated instances to the north and also west of the same region.

Dr. Loew, in his mention of Ruins in New Mexico (see A. R. 1875, and Volume VII), states that the first notice of these people (the Pueblos) was by Cabeza de Vaca, a straggler from the expedition of Narvaez in 1528 to what was then called the Florida coast.

The many Spanish narratives agree in that there were found large numbers of inhabited villages. Various writers estimate the whole Pueblo population at 50,000, while others that of a single province at 25,000. Acoma was estimated as high as 5,000, while the present number of 582 is nearly all that can comfortably exist on this little mesa summit. The estimate or count of all the present existing pueblos (19 in number) is 9,681 in all (see Annual Report Indian Bureau, 1886).

The reasons advanced for this diminution are:

(1) Change of climate in the direction of further desiccation, prompting emigration.

(2) The bloody wars with the Spaniards.

(3) Amalgamation with the Spaniards.

Ruins of once inhabited villages, cave and cliff dwellings, are found in the valleys of the Main and Little Colorado, Rio Grande, San Juan, and the Animas Fork, the Chama, Chaco, Jemez, Puerco (East and West), Zuñi, Gila, Francisco, and Bonito Rivers.

Many have been visited on the Animas River, and one writer states that in one building 517 rooms have been counted.

Stone ruins are noted at Nacimiento. Professor Cope found in the valley of Gallinas Creek and on the Eocene Plateau to the west of it the ruins of many inhabited places, with pottery, flint, implements, human bones, &c.

These were remote from water, and no traces of cisterns were found. Piñon trees of an estimated age of six hundred and forty years were noted growing in the vicinity. A conjecture is made (since these ruins were all found in positions of natural defense) that the Cibollians, put to flight during the Spanish invasion, occupied these positions, giving an age of three hundred and thirty years.

No traces of metal were found, and the present Indians can give no account of the former inhabitants of these ruins.

Independent of the annual reports and contributions to the final volumes, there was published this year a special astronomical volume, to which the late Dr. Kampf and John H. Clark contributed.

EXPEDITION OF 1875.

The operations of the season of 1875 embraced (approximately) 39,169 square miles, topographically surveyed—California 19,545, Colorado 6,216, and New Mexico 13,408 square miles.

The California, Colorado, and New Mexico divisions were entirely separated, the former making their examinations principally in the basins of the Colorado and Sacramento Rivers; the latter in portions of the Upper Arkansas, Rio Grande, headwaters of the Pecos, the San Juan, and Uncompahgre.*

The topographic results fall within Atlas Sheets 61 C, 69 B, 70 A, 70 C, 77 B, and 78 A (Colorado and New Mexico), and Sheets 65 C, 65 D, 73 (A, B, C, and D), and portions of Sheets 74, 80, and 81, in Southern California.

The Colorado section was under Lieutenant Marshall, whose report, as well as others bearing on this part of the work, is to be found in Annual Report, 1876, and in the quarto volumes.

Eight separate and distinct parties were in the field.

The cañon of the Gunnison (Colorado), below the town of that name, was the principal one visited, the description of which appears in Lieutenant Marshall's Report.

The routes of the following early explorers were crossed: Pike, 1807 (Arkansas and Rio Grande); Long, 1820; Frémont, 1844 and 1845; Emory, 1847 (Arkansas Valley to Santa Fe); Simpson, 1849, to Cañon de Chelle; Gunnison, 1853; Whipple, 1853–'54; and Macomb, 1859. (See routes on Progress Maps in Annual Reports).

Along the east base of the mountains from Pike's Peak to the southward in 1875 the sectionizing of public lands had been well advanced, the region being, however, principally a grazing one. Since later developments in the San Juan region and the throwing open for settlement the lands of the Ute Reservation, sectionizing the arable and timber, and subdividing the lands for mineral purposes, has here proceeded at a rapid rate, until it becomes a question of the near future (1883) when all the valuable arable and timber acres of this particular region will be appropriated by actual settlers and active citizens.

SAN FERNANDO VALLEY.

The San Fernando Valley is comparatively level and plain-like, lying encircled by mountains, the Santa Monica Range on the south, the Santa

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* NOTE.—The route of the officer in charge was from Caliente via Tehachipi Pass and northwestern arm of desert to Los Angeles, thence to San Fernando, thence to head of Tujunga Creek and return, thence to Santa Clara Valley, thence to Old Fort Tejon via San Francisquito and Cañada de las Uvas passes, Elizabeth Lake, &c., and thence to McGill's Peak and vicinity and return, thence to Caliente, on Southern Pacific Railroad.

Susanna Mountains westward toward the coast, the San Fernando Mountains on the north, and to the east portions of ranges, the crests of which mark the drainage-shed between the coast and the interior.

The soil is of a heavy, dark, calcareous loam. It produces all cereals except corn without irrigation, and with it judiciously applied, the yield should be largely increased and the whole made a garden. There is but little water in the valley, the creeks sinking within it (having an underground outlet to the Los Angeles River) being the Big and Little Tujunga, and Pacoima.

Artesian water ought to be found at well-selected points and at moderate depths along the northern side.

The arable area reaches about the sum of 150,000 acres. Two ranches only were noted, outside of the old mission of San Fernando and the little railroad town of same name. Gold occurs in Big Tujunga Cañon as well as iron, the latter also in Pacoima Cañon.

Argentiferous galena is found in the San Fernando Mountains. The only attempt at development in 1875 was upon a gold ledge near the head of Big Tujunga Cañon.

The San Fernando Mission is situated on the grant of that name (embracing nearly the entire valley), out of which the Encinos Ranch, covering nearly one league square, has been sold, and the old mission buildings, with their orchards and vineyards, by far the choice spots, have been confirmed in trust to the Roman Catholic Church. Not more than forty or fifty of the Mission Indians here remain, one (Don Rafael, with two wives) reported as having reached an age exceeding one hundred and ten years.

The walls of the main buildings, including the church, are of adobe, made by the Indians from the immediate soil, with rafters and joining-timbers brought from over the mountains, not less than 25 miles away. The extended and arched portico, fronting the center of the valley, is of large, flat, well-burnt brick, cemented with a hydraulic lime, hard and durable. The buildings were commenced in 1807, and the church bell bears the date of 1809.

The padres were possessed of large herds of cattle, sheep, and horses, with droves of hogs and numbers of work oxen. Their revenue came principally from the sale of tallow, soap, horns, and hides to the Russian trading-ships touching the adjacent coast. Olive-oil was also produced on a considerable scale. Near the source of the main springs that furnish water for the mission is a solid masonry tank, 10 feet in diameter and from 4 to 5 feet in depth, with pipes leading therefrom, which was evidently used as a distributing reservoir for the church and other buildings, while a much larger reservoir toward the center of the valley held the bulk of the flow, doubtless used for irrigation purposes.

The orchard yet contains vines of the Mission grape, the native cactus, pear, fig, pomegranate, olive, peach, orange, lime, cherry, and palm trees.

The route from San Fernando to Old Fort Tejon crosses the eastern end of the San Fernando Range near where the Tertiary sedimentaries of the Coast Range system overlie and join the heavy granitic rocks of this prolongation of the Sierra Nevada, and by a gentle descent crosses to the dry and sandy bed of the Santa Clara, that takes its rise near the Soledad Pass, and which (though dry in July, 1875) in times of flood is said to be a roaring stream with swift current.

The Santa Clara Valley lies in the most direct line from the coast in this latitude to the basin of the Colorado, and the pass (a good one) has been utilized by the Southern Pacific Railroad. Unfortunately no safe and commodious harbor exists on the sea near the mouth of Santa Clara Valley, as indeed is true for the entire coast from San Francisco to San Diego Wharves have been built at Buenaventura and Hueneme, where both steamers and sailing vessels can land in fine weather, but where no vessels can lie at anchor with safety during storms. The other points at which wharves have been built (lying within the coast limits of the area of 1875) are Santa Barbara, Santa Monica, and Wilmington, and also a point named Newport, to the south of the mouth of the Santa Ana. The harbor of Wilmington Bay or estuary has been improved by the Government Engineer Department by a breakwater reaching from the northerly point of Rattlesnake to Deadman's Island, made for the first part of the distance, of 12-inch sheeting piles with heavy stringers, against which the shifting sand from the ocean side had already begun to bank, and for the part nearest Deadman's Island of a double row of sheeting piles filled with heavy rocks and with ripraps of heavy boulders brought from Santa Catalina Island. This construction was found to be quite successful, and dredging was going on in the channel leading to the harbor at its entrance, for a width of 60 feet, in addition to the natural scour. The size of the harbor at its best is small. Santa Monica is but an open roadstead found within an indentation of the coast. Because of the dearth of harbors, fit for all commercial purposes, to the south of San Francisco within our borders, and because of its intrinsic merits, San Diego must some day become a port of considerable importance, notwithstanding the want of immediate back country.

Both the San Fernando and Santa Clara valleys were found to be rich in petroleum indications, while the well examined by me near the summit of San Fernando Ridge, having passed into granitoid rock below the sandstone beds, had no chance of finding oil, still doubtless good results will be reached by deep boring in the Santa Clara and San Fernando valleys (preferably the former), or among the lowest of the foot-hills.

The petroleum appears to be a product of sandstone impregnated with asphaltum, while in certain localities masses of asphaltum conglomerate are found in contact with beds of clay from which the springs bubble up. They, however, are apt to turn out superficial reservoirs, and deep boring alone in the valley depressions will fully test the country.

The route from Santa Clara Valley passes up San Francisquito Cañon to its head, thence entering a small, encircled basin, at the northwestern end of which Lake Elizabeth, the reservoir for the surface drainage of the little basin, is situated. The pass has been named "Turners," the "Soledad" (3,332 feet) lying at the eastern outlet of the valley.

It is alleged that discoveries of gold (in quantity) upon this coast, and prior to American acquisition, were made in this cañon and others along the northern side of the Santa Clara Valley. The contact between the coast-range tertiaries and the crystalline rocks of the Sierras is noted at a station about midway of the cañon.

Swarms of wild honey-bees have been observed in this region, and their capture had become a regular business of certain enterprising ranchmen.

The plains, valleys, and low foot-hills had become parched at the date of visit (July 25), the season being rated a dry one among those that year by year were apparently becoming more arid.

At the altitude of Lake Elizabeth the conifer region begins, and dense chaparral, shrub-oak, and heavy sage cover lower levels to the edge of the valley.

It is claimed by the settlers that the banks of Lake Elizabeth have been settling along the eastern, if not rising along the western, side.

The sheep have made savage work with the rounded hills facing the lake by treading out the natural grasses (principally the annual "filaree") from the roots, which, if not properly cared for, must become in a few years desert knolls. Passing a low divide one comes face to face with the northwestern arm of the Mohave Desert. At time of visit there was blowing a strong, hot wind from the northwest, thus saving one from the terrible heat of a calm day.

These breezes, that follow the passes between the Sierra Nevada and the coast ranges as avenues, are marked features of these inland regions. The usual changes of temperature disturb the equilibrium of Tulare and Colorado valleys sufficiently to cause a local flow in either direction for the greater part of each twenty-four hours, thus producing a marked, almost constant, flux and reflux of shifting currents. The steady encroachment of the desert sand carried by these oft-recurrent winds in the direction of the Cañada de las Uvas Pass is noticeable (especially at Lievre Ranch, once one of the most promising, now half engulfed and buried in sand), and much grazing ground has been swallowed up thereby and springs choked. The route hence to Fort Tejon, a station from whence the exploration of the Southern Sierras began, lay through the above pass, following a winding, romantic road to the site of the old fort, ensconced in a gladelike opening, with groves in the foreground.

SUMMIT OF MOUNT PINOS.

The best view toward the coast ranges (the ocean itself being visible) was had from a point 2 miles west of summit of Mount Pinos (a mountain to the westward of old Fort Tejon).

A fine outlook was had upon the valley of the Cuyama River, through which passes the trail from San Emidio to Santa Barbara (distance, approximate, 50 miles), and which trail would also be reached through the pass west of Cuddy's Ranch and Lockwood's Valley.

There is a sharply defined range lying west of the Cuyama, visible from the above station, called McGill's Peak, after the owner of a saw-mill, below the steepest declivity of the slope, where Government lands, as in many another instance noted in various parts of the West, were being despoiled by a non-owner, and naturally in a wasteful manner.

The local markets for timber were Tejon Ranch and the vicinities of Bakersfield and Caliente, on the Southern Pacific Railroad.

The drainage to the southwest, south, and southeast following old, eroded channels without water, is marked only by little springs. The verge of the desert is reached at the divide to the south of old Fort Tejon.

The secular, desiccating winds driving over this region, with but little cessation, are having their effect in swallowing up fresh fields with the ever-drifting sand dune, and Southeastern California, in my judgment, is becoming more and more of a desert.

The ocean currents, more heavily laden with moisture, only impinge upon the coast to the north of this latitude, while to the south they are intercepted by the pronounced and persistent coast range, which claims the greater share of moisture as a deposit.

Mines are worked for antimony and silver in the Salt Creek Cañon (reaching to the desert) just east of San Emidio.

Mineral-bearing strata have also been noted, crossing the cañon leading from Cuddy's Ranch (5,100 feet elevation).

The Frazer mine (gold) lies in the mountain of that name (immediately south of Cuddy's Ranch), on the eastern side of which copper ore (bromides and sulphides) have been discovered but not worked.

At the above elevation rye can be grown, but corn, wheat, and vegetables do not mature (so says Mr. Cuddy, an old soldier, formerly of the First Dragoons).

Buena Vista Lake, the reservoir of Kern River, that had also been embraced in the general system of irrigation planned for the southern half of the Great Tulare or San Joaquin Valley, lies in view, to the northward of the route from Old Fort Tejon to Caliente, Cal.

The only Indians along the routes in Colorado were the Uncompaghre branch of the Utes, hitherto mentioned, while in California a few of the Coast Range Indians (Diegeños), at one time reservationed near Old Fort Tejon, were encountered. With the exception of the characteristic Indian features, they might easily be mistaken for Mexicans. They gain their livelihood by working for the ranchmen. The Colorado River Reservation was visited by Lieutenant Bergland's party, where vocabularies (Mohave and Chemehuevis) were obtained by Dr. Loew, who also contributed data concerning the Pah-Utes of Mono and Inyo Counties, in California, the Kauvayas and Takhtams of San Bernardino, and of the other mission Indians of Santa Barbara, San Gabriel, San Juan Capistrano, and San Diego.

Such general observations as are made refer to the California section, a region since well known and traversed by railroads, the Southern Pacific and the Atlantic and Pacific, and brought within the domain of civilization. The most interesting is the southern section of the Sierra Nevada, with its passes and valleys, its enormous mountain masses and the high peaks, whose escarpments form the horizon of the Owen's River Valley and Owen's Lake, (3,567 above sea-level). They are a wonder to the beholder, bold beyond description and exhibiting a variety of stupendous rock carving, inspiring with awe and of which the eye can never tire.

All of the available ground of the Lower Sierra Nevada has been utilized for grazing stock, especially sheep from farther to the south in the vicinity of Los Angeles.

The timber still awaits a market except in small quantities. Ranching succeeds well in the inclosed valleys among the foot-hills, where water is sufficiently abundant.

The southern and eastern part of the Great Tulare Valley possesses a rich alluvial soil, alone wanting water to become highly productive. A proposition for irrigation on an extended scale was made by an officer of the Royal British Engineers (Colonel Brereton), who had had experience in India, but was never carried out for want of funds. Incidentally it was

WHITNEY PEAK, HIGHEST OF THE SIERRA NEVADA, NEAR HEAD OF KERN RIVER, CALA.

(CALLED ALSO FISHERMAN'S PEAK.)

1875.

learned that he placed the annual evaporation from Tulare Lake (approximately 100 square miles in area) at 6 feet.

A report by Government commissioners upon irrigation of the great valleys of California (see Ex. Doc. No. 290, Forty-third Congress, first session) affords information on this subject. The State of California has instituted special surveys looking to the critical condition of the supply of water and its useful distribution, results of which, however, have never been examined by me. After leaving the Sierras to the south and westward, a great decrease has of late years been noticed in the volume of springs and especially the smaller creeks.

FISHERMAN'S PEAK OR MOUNT WHITNEY, SIERRA NEVADA.

Plate XV.—The subject of this sketch (taken by Mr. William A. Cowles, September 22, 1875, from the summit of the peak, lying about 4.79 miles south, 37° 22′ 30″ east of the true meridian, and named as Mount Whitney by Clarence King in 1871) is the highest peak of the Sierra Nevada, and was ascended by parties of the expedition on September 24, 1875 (William A. Cowles, Frank Holland, and two others), and October 13, 1875 (Lieutenant Birnie, Louis Nell, and F. Brockdorf).

The latitude and longitude as established by observations and computations of this office (latitude 36° 34′.32″ 9 north, longitude 118° 17′ 30″ 00 west) is the first known determination of its geographical co-ordinates. The azimuths and distances from Old Camp Independence and Lone Pine will be found in the special volume of positions, &c. The adopted mean of barometric observations and computations of this office give an altitude of 14,471 and that by angles of elevation from Old Camp Independence and Lone Pine and corresponding angles of depression from the peak is 14,470 feet.

Either of the altitudes place it as the highest point measured by careful barometric observations within the territory of the United States (except Alaska); the others next in order of height, according to present known measurements, are: (1) Mount Rainier or Tacoma Peak, Oregon, 14,444 feet; (2) Mount Shasta, California, 14,442 feet (Whitney); (3) Uncompaghre Peak, Colorado, 14,408 feet. Mount Saint Elias, in Alaska (the geographical co-ordinates of which are so far only approximately determined), yet to be measured barometrically or by angles of elevation referred to a well determined land base, has been given altitudes as follows:

	Feet.
1786. La Perouse	12,672
1791. Malespina	17,851
1848. Russian Hydrographic Chart 1378	17,854
1849. Tebenkoff, Chart VII	16,938
1873. English Admiralty Chart 2172	14,970
1874. U. S. Coast Survey	19,500 ± 400

Vancouver gives no elevation (see Appendix No. 10, U. S. Coast Survey Report, 1875, page 159).

The records of this office show the mean of three readings of the barometer, taken at 4, 4.30 and 5 p. m., September 24, 1875; corrected for error and reduced to 32°, is 17,796 inches, the dry bulb thermometer being 35.3 and the wet 29°.

Similar observations at the same hour on the afternoon of October 13, 1875, were: Barometer reduced 17,840 inches, dry bulb 36.7, wet 33.2. The observations were referred to the daily means at Camp Independence, and those of Septemper 24 also to simultaneous observations at a camp near the peak, giving as a mean result 14,471 feet. Angles of elevation and depression place the summit of the peak 10,513 feet above Camp Independence flagstaff; 10,693 above our camp at Lone Pine, and 10,806 above our camp on Owen's River, near Eclipse Mill; careful barometric determinations of those points being, respectively, 3,956, 3,776, and 3,666 (the last two points being referred to Camp Independence), giving as a mean result for the altitude of the peak 14,470 feet, which is the final result adopted by this Survey. This result depends upon the altitude of Old Camp Independence, which is considered to be a well determined barometric station, the adopted mean being the result of a long series of observations taken in July and August, 1871, and October and November, 1875. Recent railroad levels furnished this office by the superintendent of the Carson and Colorado River Railroad place Independence Railroad depot 3,796 feet above sea, and Lone Pine depot at 3,720, remarking that these points are on the railroad, which runs through the lowest part of the valley some 3 to 4 miles eastward of Camp Independence and Lone Pine, which should therefore be higher, which statement is confirmed by the altitudes already adopted by this office.

These levels are dependent upon the assumed altitude of 4,985 feet for Mound House, on the Virginia and Truckee Railroad, the initial point of the Carson and Colorado Railroad, which is the altitude adopted for that point by this office.

This point should be checked by level reference to Reno, Nev., the Central Pacific Railroad level giving 4,495.79 feet for altitude of the junction of Virginia and Truckee Railroad, 200 feet east of the railroad hotel, before the results depending thereon can be taken as final.

The peak itself is a rude mass of granite, the culminating point, as shown in the sketch, being helmet-shaped. The southeastern re-entrant is an ampitheater carved by glacial action, the perennial ice-fields that have long since been dissipated in the secular desiccation of the region until the permanent snow and ice beds are but little patches in the protected hollows of northern ravines and fissures contiguous to the summit. The crest of the Sierra Nevada in this region is made up of bold granite masses, with almost a vertical front and bare denuded walls above the timber-line, which has reached, according to slope, altitudes between 11,200 and 12,000 feet above sea.

The peak proper springs from the mother mass and is, according to Clarence King's description, "like the prow of a sharp ocean steamer."

The cañons radiating from the peak as a center fall almost precipitiously from 2,000 to 5,000 feet between thin, sharp ridges, pinnacle-topped, forming crater-like amphitheaters with glacial polished slopes, the summits of which look down upon alpine lakes of deep sapphire, emerald green, and gorgeous opal tints, surrounded with snow-fields.

These naked granite walls are without vegetation, a few gnarled and twisted pines (sp. *Pinus contorta* and sp. *Pinus albicaulis*) clinging to the rocks in the deeper cañons. Several pinnacles are encountered between this peak and that first ascended and named by Clarence King, in 1871 (or what might be termed Mount Whitney No. 1, elevation 14,094 feet). This peak has since been called Mount Corcoran by the artist, Mr. Albert Bierstadt.

The watershed of the immediate peak gives rise to the following streams: Three minor heads of the southern or main affluent of Lone Pine Creek to the east; the lake amphitheater, source of an eastern tributary of the north or main fork of Kern River on the west, and one of the minor tributaries, if not the main head, of this latter stream to the northwest.

These water-ways, always fed from the everlasting snows, are soon augmented into considerable streams in season of flood by the violent, frequent, and copious precipitation at this altitude and from the melting of the winter's snows.

The peak was ascended by Cowles and party from the southwest, who states that the easiest ascent is from the east and the next best from the northwest. The party under Lieutenant Birnie approached the peak also from the southwest.

The "Hockett" trail from Visalia to Lone Pine passes south of Mount Whitney No. 1 (now Corcoran Peak), crossing the divide of the Sierra Nevada at the head of Cottonwood Creek can best be used in making the ascent from the basin of Upper Kern River.

From the summit Owen's River Valley, seen to the eastward, appears stretching to the foot-hills of the White Mountain Range (80 miles distant), the most prominent peaks of which (White Mountain, 14,245 feet, and McBride's 13,415 feet), are easily distinguishable.

The Inyo Range, with Waucoba Peak (11,137 feet) at the north, Inyo Peak, Mount Hahn, and New York Butte (10,971, 11,030, and 10,545 feet, respectively) in the center, and Cerro Gordo Peak at the southern end, hides partly from view the more easterly but more prominent range, the Telescope, which forms the western wall of Death Valley, the main peak, however (10,938 feet), being visible, while through the persistent blue haze of this desolate region is revealed but dimly Grapevine and Waguyhe Peaks, lying north and eastward. At the southern end of the Inyo Range, Owen's Lake, at an elevation of 3,567 feet, lies embosomed as a tiny mirror, joined with uncertain reflections to the Coso Mountains.

To the southward Mount Corcoran (14,038 feet), Sheep Mountain (12,921 feet), Olancha (11,251 feet), and Owen's Peak (8,626 feet) form the sentinel towers of the remaining portion of the Sierra in this direction, their glacially eroded northern fissures holding plainly visible permanent snow-beds.

The horizon to the northwest and north, embracing Kaweah Peak (over 14,000 feet), Mount Silliman (11,263 feet), Brewer (13,836 feet), Tyndall (14,260 feet approximately), and Williamson (14,360 feet), completes the immediate mountain panorama, which must be seen to be appreciated.

Valleys to the eastward and the outlying minor foothills of which, if not the actual bed of depression, that can be seen, are the Coso, Panamint, and Death Valleys. The desert toward the Colorado stretches out desolate and bare until lost in the horizon of Pilot Knob. To the north and south mountain forms mark the horizon, while to the northwest and west the Granitic rib, extending from Mount Tyndall to Kaweah Peak and its extension southward, hides even the Coast Range and Tulare Valley from view.

Dr. Rothrock, the botanist of the expedition, reports upon the lower flanks of this mountain giant the presence of *Pinus contorta*, with *Pinus ponderosa* on the gentler slopes, *Pinus albicaulis* and *Pinus Breweri* at or near timber line. Spruces also were noted, and cedars 1 foot in diameter and 40 feet high at the elevation of 10,500 feet.

Sheep graze almost to the summit of Mount Whitney No. 1 (Corcoran Peak) and Sheep Mountain, its southern neighbor.

NOTE.—As bearing upon the name to be permanently applied to this prominent mountain landmark the records found upon the summit by parties of this Survey are herewith given:

(1) "*August 18th*, 1873.—John Lucas, C. D. Begole, and A. H. Johnson, the first men on this peak, '*Fisherman's Peak*,' found to be the highest in the range, by placing spirit level on Whitney, estimated to be about 500 feet."

(2) "*September 6th*, 1873.—Carl Rabe, William Crapo, T. McDonough, and William L. Hunter."

(3) "*September 19th*, 1873.—This peak, Mount Whitney, was this day climbed by Clarence King, U. S. Geologist, and Frank Knowles, of Tule River. On September 1st, in New York, I first learned that Mount Whitney of 1871 was not the highest peak. Storms and clouds prevented me from recognizing [it] in 1871, or I should have come here then. All honor to those who came here before me.—CLARENCE KING."

(4) "J. T. Belshaw, William Crapo, W. R. Johnson, Cerro Gordo, Cal. July 7th, 1875."

(5) "John Muir, Yosemite; George B. Bayley, San Francisco; C. E. Washburn, San José. July 22nd, 1875."

(6) "*Fisherman's Peak, October 3rd*, 1875.—J. M. Hutchings, of Yosemite, on a photographic tour of the high Sierras, in company with Prof. W. E. James, photographer, climbed Fisherman's Peak and took a series of photographic views. Other persons: Dr. A. Kellogg, M. D., San Francisco; J. M. Hutchings, Prof. W. E. James, photographer, New York; Dr. C. B. White, U. S. A., Camp Independence; A. H. Johnson, guide, Lone Pine; Edward Bedford, Yosemite; George P. Stanley, Brooklyn, N. Y.; and James Fleming and John F. Cannell, U. S. A., Camp Independence. Aneroid barometer (Hutchings), 15,018 feet. Thermometer 41° (1 p. m.) Water boiled at 187° F.," &c.

The following circumstances of observation of this peak have come to my attention:

(1) A party of the geological survey of California, under Professor Brewer, of Yale College, and of which Clarence King was a member, apparently first saw this peak in 1864, and applied to it the name of Mount Whitney from the summit of Mount Brewer.

(2) Messrs. King and Cotter again apparently saw it in 1864 from the summit of Tyndall.

(3) Clarence King afterwards (1864) attempted unsuccessfully its ascent from the direction of Visalia.

(4) King, in 1871, ascended the Sierra from Lone Pine, naming what is here termed Mount Whitney No. 1, lying southeasterly, and subsequently claiming, in September, 1873, that he had ascended and fixed the name to the wrong peak in 1871.

(5) Mr. W. A. Goodyear, with Mr. Belshaw, of Cerro Gordo, were the first to discover and make known the supposed error in 1873.

(6) On August 18, 1873, passing the Mount Whitney No. 1, where Mr. King's recorded ascent and name were found, Messrs. Lucas, Begole, and Johnson proceeded to the higher peak, and justly supposing that it was unnamed, christened it Fisherman's Peak. (See copy of their record). The fact of the ascent was published in an August number of the Inyo Independent.

(7) On September 6, 1873, Carl Rabe and party ascended the main peak and measured it barometrically.

(8) On September 19, 1873, Clarence King ascended this summit from the Visalia side and made the record, a copy of which is above given.

(9) The parties that subsequently have made the ascent are, Crapo and party, July 4, 1875; Muir and party, July 22, 1875; One Hundredth Meridian Survey party, September 24, 1875; Hutchings and party, October 3, 1875; One Hundredth Meridian Survey party, October 13, 1875; Professor Langley, consulting specialist of the Signal Service, and party in 1881. The barometric altitude provisionally adopted by Professor Langley for the summit is 14,522 feet, only 50 feet higher than than the result of this office.

A military reservation of a certain number of legal subdivisions surrounding this peak has been declared by authority of the President in General Orders No. 67, of the War Department, September 26, 1883. It is understood that this reservation is for the purpose of securing the location for a prospective Signal Service station.

In the preparation of the material bearing on Plate XV, I have been greatly assisted by Lieutenants Birnie and Macomb, Mr. Francis Klett, chief of party, Dr. Rothrock, and Messrs. Louis Nell and William A. Cowles.

The most remarkable precious mineral developments of the Colorado area were in the San Juan, where this industry has become fixed and permanent, with a regular annual output, while in the flanking ridges of the Southern Sierra Nevada and in the Coast Ranges from Santa Barbara southward, gold, silver, copper, lead, antimony, and tin have been found, a little superficial work done with, however, but little careful and intelligent prospecting and less serious development. The Colorado exploration led to the discovery of an entirely new and hitherto unknown pass by Lieutenant Marshall (now called by his name), leading from the Arkansas to the valley of the Gunnison, now traversed by a branch of the Denver and Rio Grande Railroad. The different approaches to the San Juan from the north and east were all made clear. In California the profiles through the Canada de las Uvas, Tejon, and Walker Passes and their approaches were carefully laid down. The Southern Pacific had already decided upon its line, leaving the Tulare plains at Bakersfield and reaching the Colorado Drainage or Mohave Desert by the Tehachapi Pass, thence southward penetrating the Santa Clara Valley by Soledad Pass. The intricate drainage of the Southern Sierras, flowing to the Interior Basin, Mohave Desert, and Tulare Valley, was for the first time accurately mapped.

The agricultural and grazing facilities of these areas are each year being more fully utilized, while the section in question is made more accessible than ever to the east by means of the Atlantic and Pacific Railroad lately (1883) joining a branch of the Southern Pacific Railroad from Mohave Station, near the mouth of Tehachapi Pass, at the Needles on the Colorado River.

Without doubt the northwestern arm of the Great Mohave desert is encroaching upon the passes leading from it to the Tulare Valley, by ever-increasing beds of drifting sand, the loci of which not long since have been farther south and eastward. The secular desiccation common to the whole interior basin and to the desert regions of eastern or southeastern California plays its part in the sequence of desolation, already largely accomplished, and which has done the greater share of its work. The encroachment should be resisted by a careful husbanding of present sources of supply, by cleansing and fencing springs, turning creeks of any considerable size upon the cultivated acres for irrigation, and thus holding within the sub-basins all that is possible of the original moisture there precipitated.

Professor Marcou adds to the published record the result of his examinations in the Southern Sierra Nevada and adjacent coast ranges, a part of the ground having been visited by him 22 years before as a member of the Pacific Railroad exploring expedition under Lieutenant Whipple, corps of Topographical Engineers (see A. R., 1876).

The results of the botanical investigations will be found discussed in the Annual Report for 1876, and Vol. VI.

The archæological researches of 1875 were by far the most important among those accomplished during a single season, because of the fruitful and excellent results from special excavations near Santa Barbara, Cal., which were well presented by Dr. Yarrow in his preliminary report (see Annual Report, 1876), and also in Vol. VII, which report is based largely upon these collections. Dr. Rothrock and Mr. Henshaw with their usual zeal materially assisted in these findings.

In addition to the usual ornithological and botanical collections for the year, the special collection consisted of 200 Indian crania (1874 and 1875), 55 lots of modern articles, and 57 boxes of stone and other implements from graves in Southern California.

The types of this latter collection were studied by Professor Putnam at Cambridge, and the results embodied in Volume VII, and these, as well as those temporarily retained at the Washington office, have been finally deposited in the National Museum.

During this year Volumes III and V, the first of the issue of quarto publications, passed the press, the usual report was submitted, and an advance edition of atlas sheets printed. Printed meteorological instructions were issued (See List of Publications, second edition, 1881).

EXPEDITION OF 1876.

The area embraced aggregates 21,044 square miles (California 9,550, Nevada 6,700, Colorado 750, and New Mexico 4,044), and lies in the basins of the Arkansas, Pecos and Rio Grande for the Colorado portion, and in the valleys of tributaries to the Upper Sacramento and Humboldt, Carson and Walker rivers, of the Great Interior Basin.*

The routes of early Government explorers falling within the areas of this year are Pike 1807 (Arkansas Valley), Frémont in his routes 1844–'45, Lieutenant Peck 1847, and Lieutenant Abert and Peck (southeast of Albuquerque) 1846–'47, Frémont 1845 (near Walker Lake), Colonel Bonneville 1833 (Humboldt Lakes), Colonel Steptoe 1855, and Captain Simpson 1858–'59.

The Nevada portion of the area joins the southern line of the belt explored geologically by Clarence King either side of the Central Pacific Railroad in vicinity of 40th parallel (see Atlas of Geological Explorations 40th parallel).

The public land surveys had entered but a small portion of the area of this season, but wherever their stakes were found a connection was made and the record entered in the office plotting sheets, that thus becomes a permanent although unpublished record of the Government.

LAKE TAHOE REGION.

One of the crowning beauties of the Northern Sierra Nevada (the whole range being justly celebrated for its massive grandeur) is the Lake Tahoe region, the lake itself having been aptly termed "the gem of the Sierras." It is the reservoir of the waters of the upper Truckee River, and several minor streams, having a single outlet, the main Truckee.

The water is of the deepest colored and most perfect blue, scintillant from its own purity, changing to aqua marine, as seen from its banks, with a depth in the center reaching at one measured point over 1,600 feet.†

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* NOTE.—The route of the officer in charge, after leaving the rendezvous at Fort Lyon, Colo., and proceeding to that at Carson, Nev., was to Virginia City, Sutro and return via Dayton, Nev., thence to the vicinity of Lake Tahoe and neighboring mountains and return to rendezvous at Carson, visiting the stations at Ogden, Utah, both in the inward and outward routes.

† NOTE.—Systematic soundings should be made in order to establish its greatest and other depths, as well as its physical conditions and the fauna which it contains.

One of the most beautiful points on its shore is on the Nevada side, at Glenbrook, immediately opposite Tahoe on the Truckee, a location more readily accessible from the Central Pacific Railroad. The most lovely spot is at the southern end, near Tallac Point, from which the peak of that name is reached by a wide trail at a distance of approximately 10½ miles.

This peak, rising high above the surrounding foothills (9,715 feet), commands a landscape at once unique and comprehensive and equalled by few of the many wonderful mountain views of our western region.

At its foot lies Fallen Leaf Lake (lovely within itself) having an outlet into Tahoe. A perfect view of all the main body of Tahoe is spread before one, the horizon on every hand is mountain-crowned, the massive Sierra Nevada peaks—Freels, Monument, Job's, and Job's Sister (all over 10,000 feet)—lying to the south and east, with others still higher in the distant horizon. The most remarkable feature of all is in the number of lakes (large and small) to be seen within the horizon's circumference. In addition to those named (Tahoe and Fallen Leaf), there may be seen Washoe, Martell, Echo, Cascade, Gillmore, and Grass lakes, sixteen small ponds or lakelets in the Devil's Basin (nearly all visible from the peak), and eight others (all small) without names.

These little mountain lakes (belonging to the Truckee and American River basins) are mostly fringed by forests of evergreens, pine, fir, and hemlock. Sadly enough, on the eastern shores of Tahoe, and part of the southern, the flanks are being stripped for timber, to be swallowed in the Comstock mines. There seems to be no method of arresting this spoliation. It would have been well years ago had the General Government reserved the slopes leading to this lake as a permanent pleasure ground, to be regulated for the benefit of all the people, as well as a specially beautiful spot for rest and recreation for travelers from all lands.

The boundary between California and Nevada traverses it longitudinally, two counties (Placer and El Dorado) abutting on the California side, and three in Nevada (Washoe, Ormsby, and Douglas). As Lake Luzerne of Switzerland is sometimes known as the "Lake of the Four Cantons," so might lovely Tahoe be called the "Lake of the Five Counties."

INDIANS.

The only tribe encountered not hitherto visited was at Fort Yuma, where a vocabulary of the Yumas was gathered by Lieutenant Bergland.

These Indians, now decimated in numbers, are well known through the reports of the Mexican boundary and Pacific Railroad surveys and through Lieutenant Ives' report of the Expedition of the Colorado.

No new fields especially worthy the attention of settlers fell within this year's area. The part of the Great Interior basin visited belongs outside of Carson Valley, Walker and Reese River valleys (all three pretty well taken up) to the desert land, as well as portions in New Mexico on either side of the Rio Grande, the most promising of the lands on the bed of this stream being already in the hands of settlers.

The only mines of any great importance visited were those of the Comstock lode, remarkable for the richness and extent of its bonanzas, and as having contributed more than $300,000,000 to the world's stock of the precious metals.

The parties operating in four separate political divisions (California, Nevada, Colorado, and New Mexico), the peculiarities of the sections entered were necessarily great and varied.

For detailed descriptions, the annual reports and chapters on description of maps and land classification should be consulted. The Nevada portions of the Great Interior basin were particularly sterile, a region devoid of timber, scanty in grazing, wanting in water, but little available for agricultural purposes, and with scarcely any timber except near the mountain summits.

The marked exceptions to the above are the valleys of the Carson and Walker rivers.

The California region near head of tributaries to upper Sacramento contains a much larger percentage of arable and grazing lands.

Land classification sheets 47 B and 47 D (published together), embracing also a portion of the Carson Valley, contain the following approximate percentages: Arable, 6.6; timber, 27.6; grazing, 19.7; 36.1 for arid or barren, and 10.0 for lakes, ponds, and marshes.

Ranches were found dotted here and there in most of the mountain valleys, as also for Colorado and New Mexico, the classification of which is shown upon sheets (in colors) embracing the surveyed areas of 1876.

Along the route followed by parties from Fort Lyon, Colo., to Las Végas, N. Mex., the Atchison, Topeka and Santa Fe Railroad has since been constructed, while much of the territory at head of Arkansas is pierced by the tracks of Denver and Rio Grande Railroad, and Denver and South Park Railroad. In this region the railroads have taken the place of all the main wagon routes and are but forerunners of others that are finally to make the whole western mountain regions accessible to the more thickly settled parts of the nation and the world at large.

The survey of the tributaries of the Upper Sacramento and of the region to the west of Pyramid Lake points in the direction of more accessible communication from the Humboldt to the Sacramento, indicating that the route selected by Lieutenant Beckwith in 1854 (see Pacific Railroad Surveys, Vol. II), or one south of Pyramid Lake would be the more available with lesser grades, although possibly a little longer line. Doubtless at some future day this route or a slight modification thereof will be made an integral part of the Central Pacific Railroad, thus avoiding, besides difficult grades, the expense of snow-sheds and dangerous delays by snow blockades.

The following mineral and thermal springs were observed, viz: Soda Spring, near upper end of Fallen Leaf Lake, temperature 46½° F., the water of which contains carbonic acid, sesquioxide of iron, and sulphureted hydrogen (Conkling); the Hot Springs, at foot of Lake Tahoe; Sulphur Springs, on Belleville and Wadsworth freight road; Warm Springs, at the State prison near Carson; the Steamboat Hot Springs, between Reno and Carson, and the Genoa Hot Springs in Carson Valley (see Annual Reports).

The principal lakes outside of the Tahoe Group in the California region were Carson and Walker (the reservoirs of these rivers respectively), Pyramid, Honey, and Horse lakes, Donner and Independence lakes, and others (small) near the heads of the Yuba.

The headwaters of the branches of Feather, Yuba, and American rivers were for the first time accurately located and traced out, a most intricate drainage, and a portion of the western rim of the great interior basin north of latitude 39° was accurately located and much detailed topographic work accomplished at the sources of the Arkansas and South Platte, while in New Mexico much new data was gathered near the headwaters of the Pecos and Mora rivers.

Within the Great Interior Basin bench marks of the Lake of the Glacial period, discovered by King and named "La Hontan" were observed, making the second of a system of ancient lakes upon which detailed observations have been made for the careful determination of their physical characteristics.

Others are yet to be explored and investigated within the extended Great Basin area.

DIVERSION OF THE COLORADO RIVER.

The examination of this question from the foot of the Grand Cañon to the Mexican border was intrusted to a party under Lieutenant Bergland, whose report appears in the Annual Report of 1876.

The river trip of 1871 and the subsequent land explorations extending upwards along the cañon banks of the river as far as "El Vado de los Padres" and other reliable information, decided beyond all peradventure that no diversion could be made between the junction of the Grand and Green and the foot of the lower Main or Grand Cañon. Lieutenant Bergland concluded also that no diversion was practicable on account of encircling cañon walls from this point to the head of the Colorado Valley, near the Needles—a result consonant with the experience of the river examination of 1871. Interesting measurements and experiments upon velocity, flow, evaporation, high and low water were made at Stone's Ferry, Camp Mohave, and Fort Yuma.

The fall of the river at Stone's Ferry was found to be 2′.13 per mile; its section=5,723 square feet, width=480 feet, hydraulic radius or mean depth=11′.89, velocity=3′.217 per second; volume of discharge=18,410.38 cubic feet per second. The observations were made between August 9 and 12, 1875. At a modulus of 1 cubic foot per second for 200 acres, the above volume is sufficient for the irrigation of 3,682,000 acres. The surface of the water at this station (August 10, 1875) was found to be 1,097′.5 above sea, while that of the high water of 1871 reached 1,114′.5 or an excess of 17 feet.

At Camp Mohave the elevation of the surface (September 2, 1875) was found to be 704′.9 above sea, the fall per mile = 1′.2, the area of river section = 4,628 square feet, its width = 1,116 feet, mean depth = 4′.144 with a velocity of 2′.50864 per second and volume of discharge = 11,623.43 cubic feet per second (observations from August 28 to September 2, 1875).

At above assumed modulus this volume would irrigate 2,324,600 acres. The river fell 5′.11 at Mohave from July 9 to September 5, 1875. The high water of 1874 was 8 feet higher than level of September 2, 1875. At Fort Yuma (below junction of the Gila) the elevation of water (March 20, 1876) was found to be 120′.0 above sea, the area of cross-section 2,726.5 square feet, width 461 feet, fall 1′.21 per mile, mean depth 5′.848, velocity = 2′.809 per second, volume of discharge (March 15 to 20, 1876) = 7,658.74 cubic feet per second, or sufficient for the irrigation of 1,513,600 acres. The high-water mark of 1862 was 10′.19 above that of March 20, 1876.

At Stone's Ferry daily evaporations of 0″.18 and 0″.23 were observed.

At Mohave, August 30 and 31, 7 p. m. to 7 a. m., the evaporation was 0″.11, and from 7 a. m. to 7 p. m., on August 30, 0″.69, or total for twenty-four hours of 0″.8.

Lieutenant Bergland deduces an approximate annual evaporation of 95.77 inches, which would correspond to a reservoir lake sufficient to retain the flow at Mohave in September, 1875, of 556 square miles.

At Fort Yuma, in August and September, 1868, Dr. Lauderdale, surgeon, U. S. Army, measured daily evaporations of 0″.408 and 0″.409, and Lieutenant Bergland, from March 19 to April 1, 1876, daily evaporations from 0″.3 to 1″.02, or an average of 0″.5, corresponding to a reservoir lake of 570 square miles. Lieutenant Bergland found the soil in the vicinity of the Colorado Indian Reservation too porous, the canals easily undermined, fluming being in many cases necessary, and is of the opinion that levees would be necessary to prevent overflows and destruction of canals and ditches in case any system of irrigation is undertaken on a large scale.

It is safe to estimate that at high-water stages at Camp Mohave there is sufficient water to irrigate 5,000,000 acres, were the same required. The conclusion arrived at by Lieutenant Bergland is to the effect that the river could be diverted north of Fort Yuma by a cutting of 160 feet, and also the sand ridge west of Pilot Knob, and with a canal about 30 miles in length to reach the depressed area, and states that there are better points within Mexican territory. No present or prospective want will demand the former undertaking at any point below the boundary, while, were such a result necessary, doubtless the channel of New River might be utilized.

A lake surface sufficiently large to act as an evaporating reservoir for the maximum influx of waters below the Gila would not exceed 1,000 square miles in extent, hence the effect of turning the channel into the depressed basin (especially at a minimum stage) would be to establish an inclosed reservoir without ocean outlet, while a flood stage would lead to an overflow and cutting of a new and natural channel to the Gulf (lined by lagoons), which would in time become a partial tidal channel at high waters. In any event no climatic change worthy of the name, from the introduction of such a sized lake in this large desert area, would result, since the increase of relative humidity that would be experienced within the perimeter of a thousand yards would quickly be dissipated and swallowed up by the eager and absorptive dry winds of the desert and reprecipitation but little increased. The basin drained by the Colorado of the West is, approximately, 241,965 square miles, or 154,857,600 acres. It is composed of mountain valleys, plateau, mesa, cañon, and desert sections in wonderful variety.

There are three marked districts within this area, divided somewhat as follows: (1) The more desert parts, bounded on the east by the west wall of the Grand Cañon, limited on the north by the rim of the Great Interior Basin, and extending south and eastward near the head of the Salt and Gila rivers to the continental divide. (2) The plateau and cañon district, the eastern limit extending northward along the continental divide to, approximately, 37° north; thence to junction of Green and Grand; thence westward to the junction of the Great Cañon wall and rim of the Great Interior Basin; thence southerly to west wall of Grand Cañon; thence following southwestern edge of Colorado Plateau to continental divide, constituting in fact the Great Colorado Plateau entire. (3) The province of the mountains and their outliers, being, respectively, the basins of the Green and Grand rivers. The first, or desert, province is, approximately, 72,889 square miles; the plateau section, approximately, 83,986 square miles, and the mountain area, approximately, 85,190 square miles.

This special duty of Lieutenant Bergland, to which general topographic observations were added, brought him within the lines traversed by the following early explorers:

Major Emory, 1849 to 1857 (Mexican Boundary west from Yuma); Captain Sitgreaves, 1851 (on the Colorado); Lieutenants Williamson and Parke 1854 (Pacific Railroad Surveys), and Lieutenant Ives, 1858 (Exploration of the Colorado).

Not less interesting were the special explorations affording new geographical contributions in the basins and deserts north of the Mohave, extending eastward to the Amargosa, and including Death Valley, Panamint, and Owen's River and Lake (see reports by Dr. Loew in the Annual Report for 1876).

These valleys, extending eastward from the southern end of the Sierras, decrease in elevation until a tract near the central portion of Death Valley is found at a depression of nearly 200 feet below sea-level.

The depressions in order of succession (all of a general northerly or southerly trend), are the valleys of Owen's River, Panamint, and Salinas, and the desert of Death Valley and Amargosa, the four dividing ridges being the Inyo, Argus, Telescope, and Amargosa ranges. No running water is found in the desert solitudes, outside of Owen's River the withering dryness of this portion of the western desert region is perfect and equal to that found in any portion of the Sahara, but happily the area permanently desolate is but small in comparison.

EXPEDITION OF 1877.

The area of this season's work aggregated 32,477 square miles, distributed as follows: California, 6,825; Colorado, 3,825; Idaho, 8,877; Nevada, 3,066; New Mexico, 6,303; Utah, 3,350; and Wyoming, 231 square miles. This area falls within the basins of the Upper Sacramento and its tributaries and the Great Interior Basin at the west, the Great Salt Lake Basin and those of Bear and Snake rivers in the center, and the basins of the Gunnison, Arkansas, and Rio Grande in the eastern section.[*]

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[*] NOTE.—The route of the officer in charge after reaching rendezvous at Carson was thence to Virginia City and return; thence, via Truckee, to Lake Tahoe, Tallac Peak and vicinity, and return to Carson; thence to Ogden, Utah; thence to Bear Lake, via Logan, Utah; thence to Twin Creek; thence to Green River Valley and return, via Randolph and Evanston, Wyo., to Ogden, Utah.

The routes of the early explorers crossed by the western section were those of Frémont, 1843 (near Camp Bidwell); Beckwith, 1854 (from Humboldt to Sacramento Valley); Williamson, 1865 (Feather River); and in the central, Bonneville, 1833; Frémont, 1843; and Dixon, 1859 (from the Dalles to the Great Salt Lake); and Emory, 1847; Gunnison, 1853; Loring, 1859 (Salt Lake City to Santa Fe); Lieutenant Smith, 1849; and Captain Overman (1873), in the eastern section (see Progress Map).

Wherever possible the data established in these early route surveys have been utilized and their reports examined; in fact, up to and until the close of the war of the rebellion, these and the public-land surveys comprised the only surveys of this entire western region, and, as is well known, the latter are only planimetric and for a specific and single purpose (*i. e.*, subdividing land and to gather measured boundaries upon which to base its sale). Uniformly the stakes marking subdivisions within the area of a given year's survey have been joined with, wherever found. This season was marked by certain special surveys more in detail, as of the Lake Tahoe region (scale 1 inch to 1 mile), the Washoe mining district (scale $1'' = 500'$; published at 1 inch to 1,500 feet) as a basis for the systematic examination of this center of the precious metals.[*]

The Mescalero Apache Indian Agency, situated on Tulerosa Creek, southwest of Fort Stanton, New Mexico, came within the area assigned Lieutenant Morrison, who reports this region as well watered and timbered, and abounding in game. The number of these Indians in 1881 is given at 900 (see Annual Report of Indian Commissioner for 1882). Morrison states that they are below medium size, of scant angular frames, and with larger and less symmetrical bones than the Navajoes, also less intelligent and more squalid. Among them marriage is a barter for the female; the dead are buried on hills and covered with boughs and stones. The women make baskets, while some of the men labor in the fields.

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[*] One of the most interesting of the many phenomena presented by the workings of the Comstock mines is the great heat encountered at the lower levels, and it was to the investigation of the sources of this heat-supply that Mr. Church devoted much of his time. As is readily seen, the question of future increase or decrease of the temperature is a most important one in its bearing upon the prosperous working of the mines. As the result of his investigation, Mr. Church reached the conclusion that the usual explanation of the heat that exists in the eruptive rocks of many localities, namely, that it is the last manifestation of the heat which fused the rocks, does not apply here, because of the persistence with which the supply is maintained under conditions that make extraordinary draughts upon it. He considers the true source to be the chemical alteration of the feldspathic minerals in the rocks, or the process technically known as kaolinization—the changing of feldspar to clay. As to the question of increase of heat he is of the opinion that it is subject to a steady and moderate increase as greater depths are reached.

Among the areas visited and mapped in 1877 most worthy the attention of the courageous and enterprising settler, are the valleys of the southern tributaries of Snake River, west of the Bannock Reservation and of the Gunnison, all of which region is now easily accessible by rail (see description of Atlas Sheets).

Lieutenant Morrison reported prospects of gold, silver, and copper in the Sierra Blanca, near Fort Stanton, but little known and entered upon since it was embraced in an Indian reservation.

The most direct route from the head of the valley of Great Salt Lake to the Snake River was defined and measured. The Utah Northern Railroad, starting at Ogden, has since entered this ground.

A fine natural pass was noted at the head of Twin Creek (a stream entering Bear River valley), which leads to Ham's Fork of Green River. The approaches on either side were found to be superior to those on the old Bridger wagon-road to the southward. The game of this vicinity consisted (1877) of black, grizzly, brown, and cinnamon bear, elk, black, and cotton-tail deer in small numbers, with antelopes, foxes, coyotes, wolves, duck, grouse, sage hens, and rabbits in abundance; also many trout in the mountain streams.

The valley of the Gunnison, mapped in 1877, has since been opened up, largely through the energy of the Denver and Rio Grande Railroad, being availed of for a part of their route which extends west to Salt Lake City over pretty much the same line as that explored by Gunnison during the Pacific Railroad surveys (and known as Gunnison's route). A second railroad from Denver, the Denver and South Park Railroad, also reaches the valley of the Gunnison, near the town of that name.

The routes leading from Forts Craig and McRae to Stanton were carefully measured, as well as the region (a part of it the Jornada del Muerto) lying between and about the site of the Mescalero Indian Agency at Tulerosa.

The Atchison, Topeka and Santa Fe Railroad now traverses the greater part of the entire length of the above "Jornada."

THERMAL AND MINERAL SPRINGS.

Many thermal and mineral springs were noted by Lieutenant Tillman in Utah and Idaho (see Annual Report for 1878, page 110) on the Bear, Blackfoot, and Port Neuf rivers and along Mink and Salt creeks. Temperatures as high as 145° were recorded. Among the number were the well-known Soda Springs at Morristown, Idaho, near Bear River. Lieutenant Tillman observed that the carbonic acid gas escaped in such quantities that birds alighting near them are poisoned and that grasshoppers succumbed in less than two minutes.

At the Hot Springs, near Honey Lake, Lieutenant Symons observed a temperature of 210° F. at the source, found to have an elevation of approximately 4,000 feet above sea. A number of these springs are found among the flanks of Hot Spring Mountain.

Lieutenant Bergland was enabled to measure the volumes of the Rio Grande above the North Fork, as also the latter, as well as the Gunnison above the confluence of the Tumichi, and the latter stream with the following results:

Main stream (Rio Grande), June 22, 1877; width, 182 feet; maximum depth, 7 feet; area of section, 692 feet; mean velocity, 5.229 feet per second, and volume of discharge, 3,618.468 cubic feet per second. (This was at nearly its highest stage). North Fork (same date), width, 94 feet; mean depth, 3.125 feet; area of section, 196.5 square feet; mean velocity, 5.43 feet per second, and volume of discharge, 1,067 cubic feet per second, thus making a combined flow, or that of the Rio Grande below its north branch at this stage of 4,685.5 cubic feet per second.

The Gunnison, on November 5, 1877, was found as follows: Width, 75 feet; mean depth, 3.4 feet; area of section, 154.17 square feet; mean velocity, 1.57 feet per second, and volume of discharge, 242 cubic feet per second.

The Tumichi, width, 64 feet; mean depth, 1.8 feet; area of section, 50 feet; mean velocity, 2.63 feet, and volume, 131.57 cubic feet per second, thus aggregating for the Gunnison below mouth of Tumichi 373.5 cubic feet at nearly a minimum stage. This is much larger at a season of high water, when the Gunnison cannot be forded with safety.

The mean daily evaporation at Los Pinos Indian Reservation, from August 9 to 24, 1887, was 0″.5537, of which 70 per cent. occurred between sunrise and sunset, and the balance of 30 per cent. during the night.

A small cave was explored by Lieutenant Morrison and party near Fort Stanton, New Mexico, in the limestone (capped by sandstone) of the Sierra Blanca. The main line extended, approximately, 1,000 feet from opening, and two laterals were measured, one, approximately, 1,400, and a second about 1,700, feet in length. The domes, stalagmites and stalactites, and crystals were found comparatively uninteresting. (See Annual Report, 1877, page 138.)

The topographic results will be found embodied in Sheets 38 B and D, 47 B and D, 56 B, 32 C and D, 41 A and B, 61 A, 84 B, and part of 77 D. (See also description of maps.)

During the year Vol. IV (Paleontology) and Vol. II (Astronomy) of the quarto reports were issued; also the Catalogue of Mean Declinations of 2,018 stars, and the usual annual report.

Editions of final Atlas sheets 53 C, 61 C (sub), 65 D, 70 A and C, and 77 B were issued. (See "List of Reports and Maps.")

EXPEDITION OF 1878.

The area mapped aggregated 26,550 square miles (California 10,175 New Mexico 8,625, Oregon 7,600, and Texas 150 square miles).*

Portions of areas visited in 1873, 1874, 1875, 1876, and 1877 were connected with and in certain cases impinged upon.

The main basins entered were the Columbia, Great Interior, Sacramento, Coast, Mohave, Great Salt Lake, Rio Grande, Pecos, and portions of the Gila, the following being the principal streams: Columbia, Des Chutes, Upper Sacramento, Pitt, Stanislaus, Tuolumne, Merced, and branches of San Joaquin, Los Angeles, Mohave, Rio Grande, Pecos, Miembres, and Gila rivers.

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*NOTE.—The route taken by the officer in charge was from rendezvous at Carson, Nev., to Virginia, Nev., and returning, thence to Fort Bidwell via Reno, thence to Fort Klamath, thence to the Dalles on the Columbia River via Corral Springs, Des Chutes, and Crooked rivers and Warm Springs, thence to Fort Walla Walla and return, thence to Portland via Fort Vancouver, thence to Sacramento, Cal., via Roseburg, Oreg., and Redding, Cal.

The cañons of the Tuolumne, Stanislaus, and Merced rivers of the Sierra Nevada are shown on Atlas Sheet 56 D. (See description of Atlas sheets.)

The routes of the early Government explorers crossed were those of Frémont (1843), eastern base of Cascade; Warner, 1849; Derby, 1849; Stevens, 1853; Mendell, 1855; Williamson and Abbott, 1855; Beckwith, 1854; Dixon, 1859; Williamson, 1865; Emory, 1846–'47; Whipple, 1853; Parke, 1854, and Overman, 1873. (See Pacific Railroad Reports, Vols. IV, VII, XI, and later report of the Bureau of Topographical Engineers, and of Corps of Engineers and Progress Map, with the several Annual Reports.)

In these areas, in 1878, the subdivision by the General Land Office had but little entered, on account mostly of their inaccessibility, mountainous structure, and desert character; however, since that date it is learned that large areas of timber, valley, and grazing lands, and that showing mineral resources (both economic and precious), have come into the market and been disposed of to the settler.

PARTIAL ITINERARY, 1878.

Fort Bidwell to Fort Klamath.

The route from Surprise Valley to Goose Lake Valley lay via Lassens Pass (elevation 6,201 feet) of the Warner range, marking a point of the western rim of the Great Interior Basin. This pass debouches into Fandango Valley that leads into Goose Lake Valley nearly due east from the southern point of the lake of that name.

The next day the route was continued from Willow Ranch, passing through Lake View, a new town or nucleus of agricultural settlement in this vicinity, where a land office had lately been established.

Goose Lake was found to contain fresh water and plenty of trout. Along the eastern side toward the foot-hills of the Warner range, basalt, covering tabular limestone, cropping here and there was noticed. The volcanic soil is dark, tillable, and many ranches have been taken up. The valleys were found abundantly clothed with grass, and the pine timber of the surrounding foot-hills was of luxuriant growth. The succeeding day's journey lay entirely in the valley of Sprague River (discovered by and named after Major Sprague, Paymaster's Department) to Prine's Ranch.

The following day brought us (*en route* to join the main party of the California division at Fort Klamath) to Yainax, a branch of the Klamath Indian Agency. A lovely country was traversed during this day's march, all being within the Indian reservation after reaching a point a few hundred yards west of Prine's Ranch.

The march was resumed the following day, expecting to be able to reach Fort Klamath, but as luck would have it a road forking in the heavy timber was taken for the main one on account of its fresher tracks and apparently more frequent use. This proved, however, to be the old Eugene City wagon-road, and brought the party just at dusk to a little stream with abrupt banks, the bridge over which had gone to decay, thus stopping further progress. Reference to the topographical notes showed an erroneous course. The route was through heavy forests with little glade-like openings finely grassed. After a short rest and supper the back track was taken by moonlight, and camp made at about 3.30 a. m. near the fork of the roads. At daylight the march was resumed until about 3 p. m., when the open valley of Williamson's River was reached (this river was discovered by Colonel Williamson, U. S. Engineers, in his route from Sacramento Basin to Columbia River in 1865, and named after him), and later the regular Klamath Agency. The territory of this Indian reservation is spotted with tracts of fine land for farming and grazing purposes, with timber in sight from almost any point in all directions, and well watered with clear and limpid streams abounding in mountain trout. The succeeding march brought the party to the rendezvous at Fort Klamath, where the more arduous labors of the season were to begin.

Fort Klamath to The Dalles, Oregon.

The route northward to The Dalles had for an initial point the main Indian agency, to which our steps were retraced, and thence following a northerly direction camp was made on the west bank of Williamson's River, a short distance above an Indian trail, crossing the river to the eastward and passing just south of the abandoned bridge, mentioned on the Eugene City wagon-road.

Pine forests, grazing, and tillable soil are noted, respectively, on the rolling hills, the slopes next to the valley, and in the valley proper.

The succeeding day's march follows northward for a distance of 22.85 miles, the rude wagon-road, fashioned upon a natural bed, passing along the western edge of Klamath Marsh (here a meadow-like opening), thence through rolling ground, scantily timbered and grassed, crossing Sand Creek, a lively running stream of clear water, with sandy bed and banks, having its source near the summit of Scott Peak, of the Cascade Range, nearly due west. This water reaches Williamson's River through the marsh. Camp is made at "Big Springs," that burst through the basalt cap of the outlying fields of the immense eruptive flows that together gave size to the up-lift of the Cascades, flooding large areas on either side of the main axial line of upheaval and flow. The great flat surrounding Klamath Marsh is marked by stunted pines, burned in patches; larger pines toward the foot-hills rear their massive heads, lending color to the higher foot hills and mountain tops as high as 10,000 feet of the range to the westward.

Thielson Peak, a needle-shaped, inaccessible pinnacle, standing bold against the horizon, bears north 54° west from Big Springs. The report was current at Fort Klamath that a number of unsuccessful attempts to scale this mountain mass, so precipitous near its summit, have been made, but I am in doubt whether any mountain or plateau masses are inaccessible, except along certain lines of approach (instances like Thielson, and Cabezon *en route* to Fort Wingate, New Mexico, and the Grand Cañon walls, are notable as being almost, if not entirely, exempt from escalade), yet the natural erosion will always find weak lines in the rock mass, the profile of which is less abrupt and possible of access with the necessary appliances for skillful mountain climbing.

Dangerous and difficult though it may be, it still is to be doubted whether there exists any mountain peak on the globe that cannot be ascended to the summit by a well-equipped party of two or three practical and hardy explorers.

The water of the Big Springs is pure and cold. The little stream flowing from them absorbs and gives out an alkaline efflorescence.

The next camp is made at Corral Springs, a short distance west of the main route, north and on the Eugene City road, distance 21.64 miles. Meadows, upper tributaries of Klamath Marsh, were passed during the day, surrounded with pine forests, increasing in size and density as the foot-hills are reached.

Here the party is divided, one portion going westward to explore the Eugene City Pass of the Cascades, the parks adjoining, and the headwaters of Des Chutes River, while the remainder follow the road northward to Little Meadows, on the Des Chutes River.

The route to this point lay entirely through an almost unbroken forest of Oregon pine (*Pinus ponderosa* prevailing).

Emigrant wagons were passed since leaving Williamson's River, of pioneers from Ohio, Indiana, and Illinois, the owners of which, having exhausted the search for lands of promise in a due western direction, had now turned their faces northward and were aiming for the Pelouse River region. Thus the roving instincts of mankind help to point out and determine the land, paving the way to its settlement and to dots among the world's productive areas. The soil and exposed rock still remain persistently volcanic (a comparatively late basalt). Walker Range, lying to the east, a low serrated ridge, marks a part of the perimeter of the northwestern arm of the Great Interior Basin, and its most westerly point is found (centrally) in this range, at longitude 121° 40′ west of Greenwich (approximately).

The route hence to Crooked River followed the Des Chutes to Farewell Bend, and thence across a volcanic desert for more than 30 miles, to Carmical's Ranch, on Crooked River, at which point a route westward to the Willamette Valley crosses the Cascades at an elevation of 3,154 feet, near Fish Lake, between Mounts Jefferson and Washington. At Big Meadows and Farewell Bend stock raising was carried on in a small way. The whole upper Des Chutes River is valuable for agriculture in the bottoms, grazing at average altitudes, and for timber to the very summit of the Cascades, and offers fine inducements at least to the pastoral class.

Game proved abundant everywhere in the valley of the Des Chutes, and fish were plentiful (especially mountain trout) in the streams. The larder was generally well supplied with dressed venison and antelope meat and trout daily caught. Bear (grizzly, brown, and black) are of common occurrence in the mountains.

Crooked River was settled at a place called Prineville, and again by ranches toward its source, by pioneers who had crossed the Cascades from the Willamette Valley, pushing farther into the wilderness. The route from Carmical's followed northward for about 15 miles, to Willow Creek settlement, then north and west to Perry, on the Des Chutes, near the Warm Spring Agency. The country passed over was a rolling mesa (still basaltic soil), covered with a luxuriant growth of grass, and with pine thickets occasionally interspersed. At Willow Creek farming was carried on, but elsewhere grazing, one of the camps having been made at a small ranch, the ground and home of a sheep-herder (an Englishman) from Australia, caring for herds belonging to stock-growers who had begun their career and made their first attempt in Australia.

About 6 miles from Carmical's, on the summit of a small butte to the west of the road, a most beautiful and comprehensive view of the Cascades from Mount Scott on the south to Mount Adams on the north was had.

A slight rain in the night had been a snow fall in the mountains, and the high peaks were all covered to below timber line, presenting the appearance of huge rough diamonds in an emerald setting. The morning was sunny and clear, and the vision entirely unobstructed by excess of humidity or haziness. There were visible, counting from the southward, the following peaks (each worthy a special description): Scott, Thielson, Diamond, Davis, Black Butte, Baldy, Saint Mary, the Three Sisters, Washington, Jefferson, Hood, and Adams, twelve in all. No similar or as extensive a mountain panorama was elsewhere encountered in travels in the West, and one can easily believe it to be worthy of comparison with like panoramas in the Himalayas seen from the crests of their subordinate or outlying foot-hills.

Warm Spring Agency, one of the advanced Indian outposts, was reached, where the Indians were under the guidance of Captain Smith, an enthusiast, and a comparatively large number were engaged in agricultural and pastoral pursuits. From this point it became necessary to make a hurried trip through the settlements of Oak Grove and Tygh Valley to Dalles, on the Columbia River, to inspect astronomical stations and pay attention to affairs in other parts of the widely distributed expedition of this year. Lieutenant Symons passed over portions of the same line later in the season. (See Annual Report, 1879.)

INDIANS.

The Klamath Indian Reservation was found to be the home of a number of the Klamath, Modoc, and Snake tribes.

The total population, as given in report of Indian Commissioner for 1886, is 972. A subagency for farming purposes at Yainax, on the southern edge of the reservation, together with the main one at Fort Klamath, were the headquarters of the Government employés belonging to the Klamath agency. The question of actual and final boundary was in dispute; the area claimed is approximately 1,056,000 acres, or an average of 1,086 for each man, woman, or child. The Warm Spring Indians, numbering 859 according to the Indian Commissioner's Report of 1886, were found to be well advanced in the art of agriculture, many of them living in wooden houses, using plows and other modern implements, transporting their crops by heavy teams, under an enthusiastic agent advancing toward the idea of individual ownership of land, if not citizenship.

The section of territory visited in 1878 found to contain the most inducements to the settler on account of agricultural and grazing values lies along the entire length of the Des Chutes Valley in Oregon, at the sources of the Klamath, Williamson, and Sprague rivers (part of Klamath Indian Reservation) and about the headwaters of the Colorado Chiquito, San Francisco, and Gila rivers in New Mexico. The soil in the former localities is drawn direct from the heavy rich basalt of the Cascades, and in the latter principally from trachytes and rhyolites of the Colorado Plateau, being rich in carbonates of lime and magnesia, potassa, and phosphoric acid.

Regions notable for heavy timber (especially of the conifer species) are the summits (except the high peaks) and flanks of the Cascade range, the western flanks of the Sierra Nevada, the Miembres range in New Mexico, as also the mountains and mesas about the headwaters of the San Francisco, Colorado Chiquito and Gila rivers, this section marking the southern extension of the great and almost unbroken forest commencing north and west from San Francisco Mountain, heretofore mentioned.

Ranches, mainly of herders for stock-raising purposes, already dotted a part of these regions in 1878 (see Annual Report, 1879), and while the amount of arable ground is not relatively so great (see chapter on land classification), still, together with that fit for grazing, and the large masses of timber, independent of the minor resources only faintly developed, give promise of the general occupancy of these territories by thrifty settlers.

The condition of the mining industry undergoes an annual increase and expansion until the records of the subdivisions required in obtaining title form no inconsiderable feature of the labors of the General Land Office.

The routes particularly worthy of mention lying within the area of the 1878 survey are those from Fort Bidwell to Fort Klamath via Klamath Indian Agency, and from the latter point to The Dalles on the Columbia River (see Special Report, list of geographical positions, &c.); also that from Fest's Ferry on the Rio Grande to near headwaters of Little Colorado at Springerville, a route along which railroad communication could easily be had with the Atchison, Topeka and Santa Fe Railroad, near Eagle Station, due east from Fest's Ferry, and the Atlantic and Pacific Railroad, at Holbrook, on the Little Colorado, thus making another direct connection between San Francisco and the Gulf ports at Galveston and New Orleans, by utilizing the branch of the Atchison, Topeka and Santa Fe Railroad extending to El Paso. The approximate length of road necessary to build would be 200 miles, from Holbrook, on Atlantic and Pacific, to Eagle Station, on Atchison, Topeka and Santa Fe Railroad.

While the route or routes followed by the parties of 1878 from the basin of the Rio Grande to that of the Little Colorado may not be the most available, still a practicable line can doubtless be found along several routes, and I look for such a link in the connection from San Francisco to the Gulf of Mexico as something of the near future.

The distance from Mohave Station, on Southern Pacific Railroad, to El Paso is stated at 940 miles, and that from the same station to Holbrook, in valley of Little Colorado, 564 miles, and the remaining distance to El Paso (allowing 200 miles of road to be built) is 314 miles, or a sum total of 878 miles, making a saving in distance only of approximately 25 miles. A north and south line, meeting rail communication at head of Sevier River, could cross the Colorado at mouth of Paria and join the Atlantic and Pacific Railroad at Sunset crossing, in which event the link from the Little Colorado to the Rio Grande would complete the chain of connection from the heart of the western mountain region to the Northeastern and Eastern Mexican States and tidewater at Galveston.

Crater or Mystic Lake, a singular mountain reservoir, lies near to and north of the summit of the divide (Cascade Range) between the upper Klamath Valley and the head of Rogue River, a distance, approximately, of 23 miles from Fort Klamath.

The elevation (barometric) of the lowest point on its southern rim is 7,143 feet above sea, giving an elevation of 6,243 feet for the surface of the water.

The route out of Klamath Valley crosses Wood River, then ascends Annie Creek, that takes its rise in the basaltic cap near the summit of the divide and at an elevation permitting of the source being fed subterraneously from this lake, the right line distance through rock to the edge of the lake being approximately 2 miles.

The road is entirely along a volcanic floor, through thick pines, spruce, and firs. A suite of nine distinct layers of volcanic rock is shown on the precipitous walls of the bowl-shaped reservoir, that is 900 feet deep from lowest point of southern rim, and not less than 2,000 feet at the northeast angle opposite Mount Scott, of the Cascade Range.

Snow lies nearly the entire year about the basalt rim, but the drainage is always from the interior or lake surface along the entire perimeter, except for a trifling surface drain at the most depressed or southerly point. The usual snow and rains are apparently the only feeders.

It is believed that the water, which is clear and pure, does not freeze during the winter. It is certainly unique among all lakes the characteristics of which are known to me. Its bed has evidently been in the past the amphitheater of long-continued volcanic activity, and appears to be in shape somewhat like the basin of Kilauea, one of the largest of the present active volcanos of the Sandwich Islands.*

The water-line on a bold detached rock pedestal or shaft showed a rise above the then level of nearly 6 feet.

A crater island or black basaltic frustum towers from the surface at the western side of the lake (about 2⅜ miles from extremity of lake opposite Mount Scott), the elevation of its summit being approximately 2,500 feet above the water's edge. This cone is covered with scattered pines nearly to the top. There is no evidence on the blackened rocky shore of fish, animal, or plant life. Small nodules of pumice floating slowly past evidence a very slight movement of the water. Its dimensions are approximately 3 by 2½ miles and oval shaped, with contractions at ends of minor axis.*

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* Captain Dutton, U. S. Ordnance, gives the following dimensions for the volcanic vent known as Kilauea, on the island of Hawaii: "A pit about 3¼ miles in width, nearly elliptical in plan, and surrounded with cliffs for the most part inaccessible to human foot, and varying in altitude from a little more than 300 feet to a little more than 700 feet." (Fourth Annual Report U. S. Geological Survey, p. 104.)

He suggests the term *caldera* for the very limited class of amphitheaters, of which this may be considered a type. Mokuaweoweo, the caldera found at the summit of Mauna Loa, about 22 miles from Kilauea, northwestward, has horizontal dimensions somewhat less than the latter, while a depth of 600 feet is stated for one point on its rim. He accounts for the shapes of the peculiar depressions, some of which still remain as active volcanic vents, as follows: "Numerous small crateriform depressions are found in many parts of Hawaii, which also seem to me to be homologous to Kilauea, some of which are only a few hundred feet in diameter, and none of them exhibit any signs of recent activity. Considered with reference to their origin, the evidence is conclusive that they were formed by the dropping of a block of the mountain crust, which once covered a reservoir of lava, this reservoir being tapped and drained by eruptions occurring at much lower levels."

It was stated that soundings had been made and a depth of 750 feet found. Thielson's Peak stands athwart the northern rim as seen from the camp at the south, and about 16 miles distant. A heavy growth of pines, spruce, and fir approach the rim from every side, extending where possible to obtain a foothold along the cañon escarpment toward the lake below.

This unique mystic basin, mountain locked, set deep in the heart of the Cascades, marks a well-preserved opening that has once led to those interior laboratories of nature, the molten volumes from which still demand, although with waning force, outlets at many points through the earth's crust, leaving often, as in this instance, rivets holding together, as it were, the solid formations temporarily rent asunder.

In the northwestern arm of the Great Interior Desert are found Abert, Chewaucan, Summer, Silver, and Pauline lakes, which, with exception of the latter, are reservoir sinks. No lakes are reported within the New Mexico district. (See Atlas sheet 84.)

The only thermal or mineral springs reported are mentioned by Lieutenant Birnie as the most important group in Southwestern New Mexico, the principal one, or Hot Spring, being situated at about 21 miles from Fort Bayard on road to Miembres.

The temperature is 150° F., that at Apache, Idaho, 89° F., and that of another spring near, 120° F. They all have a copious flow and are noted for their curative properties.

The western rim of the Great Interior Basin was traced for a distance of approximately 2° of latitude to the north of Fort Bidwell, or, say, California boundary, and many points determined that define the shape of its considerable northwestern arm. Thus by installments this peculiar inland feature of the far western mountain and plateau region has been brought to light, additions to its extent and physical configuration having been made by each of the expeditions, beginning with that of 1869. It finally figures upon the present map of the globe as the largest known *determined* area without surface drainage or outlet to the ocean.

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* Its geographic and topographic position is to be found delineated on one of the original unpublished plotting sheets among the archives of the Engineer Department.

The northern limit of its northwestern arm is found to be approximately 44° 20′ north latitude, and its extreme western at, approximately, longitude 121° 40′ west from Greenwich.

The approximate eastern and southern limits are 111° west longitude and 33° 45′ north latitude, respectively, thus embracing substantially 10° 40′ in longitude and 10° 35′ in latitude, with an approximate area of 208.600 square miles.

LIST OF PRINCIPAL PASSES ACROSS THE WESTERN RIM OF THE GREAT INTERIOR BASIN.

This list, prepared by and under the direction of Lieutenant Macomb, is intended to show in a single view all the passes or gaps at present traversed by trails, roads, or railways crossing the western portion of the divide between the Interior Basin and the Pacific water-shed.

The passes are arranged in the order of their occurrence from north to south, the altitude of the summit of each being given, together with that of the principal adjacent peaks. In the column of remarks will be found the name and character of the route of communication through the pass.

The divide on the north follows the crest of the Great Desert Plain of Central Oregon, and, passing some 19 miles eastward of the Cascade Range, runs west of Summer Lake, over the "Winter Ridge" of Frémont (locally Rim Rock Mountains), and through the Warner Range, lying between Surprise Valley and Goose Lake, and thence through a comparatively low rolling region west of the Madeline Plains to the vicinity of Lassen's Butte. From here south it follows the crest of the Sierra Nevada, rising gradually to its maximum elevation at Fisherman's Peak or Mount Whitney, and then descending more rapidly toward the south as the great Sierra falls away in the Coast Ranges of Southern California. Only three passes out of the list of seventy-nine are used by railroads; others are traversed by main or through wagon-roads, while the remainder are crossed by local wagon-roads or trails.

The railroad passes are distinguished by SMALL CAPITALS and those used by main wagon-roads by *italics*.

Except where stated to the contrary in the column of remarks, all of the passes mentioned have been visited by parties of this survey, and the altitudes have been obtained from their barometric observations. Other authentic results, where known, have been noted for comparison, when there is no doubt as to the identity of the pass.

To avoid any misunderstanding as to locality, the approximate latitudes and longitudes, with distances and directions of the principal peaks, have been given, as shown by the plots of this office.

Number.	Approximate position.				Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.		Longitude.		Name.	Height.	Name.	Height.	
	°	′	°	′		Feet.		Feet.	
1	43	44	119	52	*Camp Curry*	5,512	Crest of Great Desert Plain of Central Oregon; no marked peaks or divide.	......	Prineville and Harney wagon-road.
2	43	37	120	45	*Langton's*	5,225	......do	......	Lakeview and Prineville wagon-road.
3	42	45	120	52	Sycan	6,000	Winter Ridge; no marked peaks.	......	Trail west from Summer Lake to old Eugene road.
4	42	24	120	24	*Chewaucan*	5,731	No marked peaks; divide low.	......	Lakeview and Prineville road.
5	42	19½	120	18	Antler	4,829	No marked peaks; divide very low; a pass in main crest of Warner Mountains, 5 miles east, is 6,885 feet.	......	Wagon-road, Drew's Valley to Antler Post-Office.
6	42	13½	120	19	*Warner*	5,820	Sugarloaf, N. 80° E., 10½ miles.	8,416	Old Oregon and California military road; present road from Lakeview to Warner Lake Valley.
7	41	54½	120	15	*Bidwell*	7,204	Fandango Peak, southward 3½ miles.	7,946	New Ayres grade, between Bidwell and Lakeview.
8	41	49	120	13	Lassen's	6,201	Fandango Peak, northward 3½ miles.	7,946	Old Lakeview and Bidwell road. Altitude above Fort Bidwell from Lydecker's tables.
9	41	30	120	17	Lake	7,094	Cedar Peak, southward 8 miles	8,300	Wagon-road from south end Goose Lake Valley to Surprise Valley.
10	41	33¼	120	15¼	Cedar	6,336	Cedar Peak, northward 1 miles	8,300	Alturas and Cedarville road.
11	41	04½	120	29½	*Alturas*	5,500	Divide low; peaks from 800 to 1,000 feet above pass.	......	Susanville and Alturas road, divide between Madeline Plains and South Fork of Pit River.
12	40	30	......		Madeline	5,736	Divide low; no prominent peaks.	......	Lieutenant Beckwith's route, Pacific Railroad Reports.
13	40	29¾	121	24¼	*Noble*	*5,963	Lassen's Butte S. 37° E., 6¾ miles; not in main divide, though highest.	10,437	Sacramento Valley and Fort Crook road, divide between Canoe and Battle Creek.

* 6,074, Lieutenant Beckwith, Pacific Railroad Reports.

Number.	Approximate position.				Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.		Longitude.		Name.	Height.	Name.	Height.	
	°	′	°	′		Feet.		Feet.	
14	40	30	121	13½	*Poison Lake*	5,400	Unnamed point, S. 42° E	7,419	Honey Lake Valley, Susanville, and Fort Crook road.
15	40	27	121	01½	Fredonyer	5,670	Unnamed peak, S. 52° E., 5 miles.	7,083	Cross-road between Susanville and Fort Crook road and Susanville and Red Bluff road.
							Unnamed peak, N. 72° W., 3½ miles.	6,649	
16	40	21½	120	52	*Susanville*	5,507	Unnamed peak, N. 87° W., 5½ miles.	7,023	Susanville and Red Bluff road.
							Unnamed peak, S. 28° E., 6¼ miles.	7,406	
17	40	10	120	44	Gold Run	6,425	Unnamed peak, S. 52° W., 4½ miles.	7,496	Susanville and Taylorville road.
							Unnamed peak, S. 76° E., 2½ miles.	7,067	
18	40	18½	120	28½	Thompson	6,622	Thompson peak, N. 67° W., 4½ miles.	7,752	Ranch-road from Honey Lake Valley to Thompson Creek.
							Milford Peak, S. 37° W., 4 miles	8,578	
19	40	07½	120	20½	McFadden	5,900	Milford Peak, N. 55° W., 6 miles	8,578	Ranch-road from Honey Lake Valley to Thompson Creek Basin.
							McKesick's Peak, S. 65° E., 2½ miles.	7,068	
20	40	01½	120	11½	Last Chance	6,006	McKesick's Peak, N. 81° W., 5½ miles.	7,068	Local road from Long Valley to Last Chance Valley.
							Adams Peak, S. 23° E., 8½ miles.	8,432	
21	39	47½	120	06	*Beckworth*	5,198	Adams Peak, N. 1° E., 3½ miles.	8,432	Wagon-road from Reno to Beckworth post-office.
							Summit Peak, S. 18° W., 6½ miles	8,302	
22	39	39½	120	08	Loyalton	7,075	Summit Peak, N. 8° W., 2½ miles	8,302	Wagon-road between Loyalton and Reno.
							High ridge, south	8,020	
23	39	33½	120	00	Sardine Valley	6,340	High ridge, northeast	8,020	Truckee and Loyalton road.
							Peak, southwest 2 miles	8,062	
24	39	32½	120	13½	Sierraville	6,865	No marked peaks near........	....	Wagon-road from Reno to south end of Sierra Valley.
25	39	30½	120	16½	*Sierra Valley*	6,831	Ridge rises 700 to 1,000 feet above passes.	....	Wagon-road from Truckee to south end of Sierra Valley.
26	39	38½	120	38½	Yuba Gap*	6,700	Haskell's Peak, N. 30° W., 5 miles.	8,136	Wagon-road, Sierra Valley to Sierra City. Whitney gives 6,642 feet altitude of this pass.
							Downieville Buttes, S. 61° W., 9 miles.	8,541	
27	39	40½	120	27½	Haskell's*	6,815	Haskell's Peak, S. 76° W., 5 miles.	8,136	Wagon road, Sierra Valley to Quincy.
							Beckworth Butte, N. 12° E., 6½ miles.	7,280	
28	39	29	120	26½	*Henness*	6,956	No marked peaks near, ridge rises 400 to 800 feet above passes.	....	Henness Pass wagon-road. Whitney gives 6,986 feet.
29	39	25	120	27	Meadow Lake	7,677	....	....	Branch road to Meadow Lake mining district from Henness Pass road.
30	39	19	120	19½	*Donner*	7,043	Castle Peak, 2½ miles northward.	9,012	Summit of wagon-road from Truckee to Emigrant Gap.

* Yuba Gap and Haskell's Pass are not in the main divide, but in the high spur west of Sierra Valley, terminating northward in Beckworth Butte. The main divide bends sharply eastward about 17 miles south of Beckworth Butte, while the spur runs directly north.

Number.	Approximate position.		Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.	Longitude.	Name.	Height.	Name.	Height.	
	° ′	° ′		Feet.		Feet.	
			Donner	6,966			Summit Station, Central Pacific Railroad. Whitney gives 7,056 feet and railroad levels 7,018 feet for summit.
31	39 12½	120 16	Soda Springs	7,998	Granite Chief, 1½ miles southwest.	8,876	On trail between Squaw Valley and Soda Springs.
32	39 11½	120 16½	Squaw Valley	8,038	Granite Chief, ¾ mile northwest Rocky Point, south	8,876 8,765	Trail from Squaw Valley to American Valley runs over this gap.
33	39 04½	120 13¾	Blackwood	7,704	Twin Peaks, north 2½ miles	8,824	Trail to head of Blackwood Creek.
*34	39 02	120 12	Burton, or Georgetown.	7,184	Ellis Peak, northward 2½ miles.	8,675	Georgetown and Lake Tahoe trail. Whitney gives 7,119 feet and railroad levels 7,184 feet for this pass.
35	38 49¾	120 01½	Johnson's	7,396	Pyramid Peak, N. 70° W., 7 miles. Red Lake Peak, S. 17° E., 8 miles.	10,052 10,120	Simpson gives 7,222 feet, Central Pacific Railroad survey 7,373 feet as altitude of this pass.
36	38 41½	119 59¾	Carson	8,634	Red Lake Peak, N. 13° E., ½ mile. Alpine Peak, S. 12° W., 2 miles	10,120 10,436	Summit of Amador and Nevada wagon-road. Whitney gives 8,759 feet altitude of this pass.
37	39 13	119 54	Franktown*	7,960	Rose Peak, N. 5° W., 8½ miles. Marlette Peak, S. 19° W., 2½ miles.	10,820 8,831	On trail between Hot Springs (Lake Tahoe) and Franktown.
38	39 10¾	119 52¾	Marlette*	8,285	Marlette Peak, 1 mile northwest. Unnamed peak, southward 1½ miles.	8,831 9,190	Summit of wagon-road from Carson to Marlette's Lake, via Ash Cañon.
39	39 05½	119 53½	*Tahoe**	7,186	Unnamed peak, N. 10° E., 2½ miles. Genoa Peak, S. 11° E., 4 miles.	9,100 9,155	Carson and Glenbrook (Lake Tahoe) stage-road.
40	38 58¾	119 53½	*Daggett's**	7,297	Genoa Peak, N. 6° E., 4½ miles. Monument Peak, S. 6° W., 4 miles.	9,155 10,085	Summit of Kingsbury grade. Simpson gives 7,180 feet for this pass.
41	38 50	119 54¾	Freel's*	8,665	Freel's, N. 20° E., 1½ miles	10,849	Summit of trail from Lake Valley to Hope Valley.
42	38 47½	119 56¾	Luther's*	7,681	Freel's, N. 20° E., 3½ miles Stevens, S. 20° W., 4½ miles	10,849 10,010	Old stage-road from Hope Valley to Lake Valley. Simpson gives 7,305 feet for altitude of this pass.

*The six passes from Franktown to Luther's, inclusive, are not in the main crest of the Sierra, but in a lofty spur forming the eastern barrier of the Lake Tahoe Basin and separating it from the Carson Valley. This spur diverges from the main ridge just north of Carson Pass, at Red Lake Peak (latitude 38° 42½′, longitude 119° 59′, altitude 10,120 feet), running approximately N. 20° E., to Freel's Peak, and thence almost due north some 35 miles, to the cañon of the Truckee River, in latitude 39° 30′. This spur is very narrow, being less than 6 miles wide at Genoa, and very lofty, its main peaks, Freel's on the south and Rose on the north, rising 800 feet above the highest in the main divide west of Lake Tahoe. Its topographic details are well shown on the special map of the Lake Tahoe Region, and the name Tahoe Mountains has been proposed for it. Locally it is called the "Eastern Summit," in contradistinction to the main ridge across the lake, which is here known as the Western.

Number.	Approximate position.				Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.		Longitude.		Name.	Height.	Name.	Height.	
	°	′	°	′		*Feet.*		*Feet.*	
43	38	39	119	57½	Blue Lake	*8,900	Alpine Peak, N. 72° W., 2 miles	10,438	Northwest of Upper Blue Lake, on old wagon-road, near the site of Summit City mining camp.
44	38	38½	119	55	Charity..............	8,290	Peak west of pass, ½ mile .... Markleeville Peak, N. 30° E., 2 miles.	9,455 9,421	Summit of wagon-road between Charity and Hermit valleys; road crosses main divide at about 1½ miles south, at a point about 100 feet lower.
45	38	32½	119	48½	SILVER MOUNTAIN (or Ebbet's).	7,630	Highland Peak (Silver Mountains), east 3 miles.	10,936	Big Tree wagon-road, between Sonora and Silver Mountain. The highest point on the road is on the divide between the Mokelumne and Stanislaus rivers, 8,157 feet above sea and about 6 miles west of the main crest of the Sierra.
46	38	30	119	45½	Wolf Creek (north) Wolf Creek (south).	8,438 8,729	Highland Peak, northward 3 miles. Arnot Peak, southward 2 miles	10,936 10,066	These gaps are at the head of Wolf Creek and crossed by trails.
47	38	19½	119	38	*Sonora*	9,660	Sonora Peak, north 1½ miles .. Leavitt's Peak, southward 3 miles.	11,444 11,553	Summit of Sonora and Mono stage-road.
48	38	12½	119	37½	Relief (north) ...... Relief (south)	9,386 9,565	Peak, 1½ miles north.......... Tower Peak, S. 44° E., 6 miles.	10,829 11,719	Old Relief trail crosses north gap.
49	38	03	119	19	Green Creek.........	10,161	Matterhorn, northward .... Conness Peak, southward.....	12,260 12,552	On trail from Bridgeport to Yosemite Valley; pass is on main divide; small lake in pass.
50	38	02½	119	17½	Virginia Creek	11,046	Dunderberg (Castle) Peak, 1½ miles northeast. Conness Peak, 5½ miles southward.	12,380 12,552	Summit of Bridgeport and Yosemite trail, on divide between Virginia and Green creeks; pass not on main divide.
51	37	54½	119	15	*McLane's*...........	10,165	Dana, 2 miles southeastward.. Conness, 5½ miles northwestward.	13,043 12,552	Summit of Great Sierra wagon-road; altitude estimated from Whitney.
52	37	51½	119	12½	Mono..................	10,765	Dana, 3 miles northward	13,043	Summit of Mono trail, head of Bloody Cañon; altitude from Whitney.
53	37	37	....		Long Valley	9,200	Minarets to westward .... Red Slate Peak, southeastward.	12,266 13,147	On trail from Chiquito Meadows to Long Valley. Altitude from Whitney.
54	37	38	....		San Joaquin	12,400	Red Slate Peak, northwestward	13,147	Summit of trail from San Joaquin Basin to Owen's River Valley; altitude from Whitney.

* Estimated.

Number.	Approximate position.		Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.	Longitude.	Name.	Height.	Name.	Height.	
	° ′	° ′		Feet.		Feet.	
55	36 46	....	Independence	......	Black Peak, northward .... Kearsarge Peak, northward, and Williamson's Peak, southward.	13,000 12,513 14,000	Pass just south of Kearsarge Peak, on trail from South Fork of King's River to Independence.
56	36 33	....	Unnamed pass	12,057	Fisherman's Peak, or Mount Whitney, northward. Corcoran Peak, southeastward.	14,470 14,094	Altitude from Whitney; trail to Whitney's Peak from Lone Pine said to run over this pass.
57	36 25	118 11½	Visalia	10,175	Corcoran Peak, northward 8 miles.	14,094	Visalia and Lone Pine trail; also called "Hockett trail."
58	35 39½	118 01½	*Walker's*	5,302	No marked peaks; crest of ridge 1,000 to 1,300 feet above pass.	....	Wagon-road between Weldon and Coyote Holes. Altitude from Williamson's Pacific Railroad Report, 5,302 feet.
59	35 29½	118 06	Bird Spring..........	5,417	No marked peaks near; crest of ridge 1,000 to 1,300 feet above pass.	....	Old wagon-road from Weldon to Mohave Desert, via Bird Spring; probably same as Humpahyamup Pass of Williamson (altitude 5,351 feet).
60	35 27	118 14	Saint John's Mine ..	5,082	Pah-ute Peak, 7½ miles westward.	8,342	Wagon-road from Weldon to Kelso Valley.
61	35 20½	118 17	Caliente	5,407	No marked peaks near; crest of ridge about 800 feet above pass.	....	Trail from Caliente Springs to Kelso Valley.
62	35 17½	118 24	TEHACHAPAI	4,025	Double Peak, S. 29° W........	8,263	Southern Pacific Railroad; altitude by railroad levels. Williamson gives 4,020 feet Pacific Railroad Report.
63	35 11½	118 29½	Oak Creek..........	6,904	Double Peak, about ½ mile northward. Peak, south about 1 mile	8,263 8,347	Trail from Nation's, Tejon Creek to Oak Creek.
64	34 50	118 23	Tejon..............	5,465	Peak, N. 61° E, 3½ miles	8,347	Summit of trail between Tejon Creek and Dearborn's Ranch, south of Twin Lakes.
65	34 48½	118 51½	*Cañada de las Uvas.*	4,256	No marked peaks near; on divide between Tejon Creek (Tulare Basin) and Peru Creek (Santa Clara Basin).	....	Wagon-road from Elizabeth Lake to Bakersfield. Williamson's altitude 4,256 feet.
66	34 48½	118 48½	Cañada de las Uvas.	3,366	No marked peaks near; on Great Interior Basin divide.	....	Wagon-road from Elizabeth Lake to Bakersfield.
67	34 30½	118 23	*San Francisquito* ...	3,533	No marked peaks near; head of San Francisquito Creek.	....	Summit of wagon-road from Newhall to Elizabeth Lake. Williamson's altitude 3,718 feet.
68	34 21½	118 07½	SOLEDAD (or Williamson's New Pass).	3,210	No marked peaks near........	....	Southern Pacific Railroad; altitude from railroad levels. Williamson gives 3,164 feet.

Number.	Approximate position.		Name and height of pass.		Prominent neighboring peaks, with approximate distance and direction from pass.		Remarks.
	Latitude.	Longitude.	Name.	Height.	Name.	Height.	
	° ′	° ′		*Feet.*		*Feet.*	
69	34 21½	117 45½	Rock Creek	6,763	Peak, ½ mile northeast Peak, 1 mile southwest	7,576 8,421	Trail between Rock Creek and Prairie Fork of San Gabriel Creek.
70	34 20	117 37	Swarthout's Cañon	6,670	Peak, 1½ miles southwest	8,445	Road head of Swarthout's Cañon.
71	34 22½	117 35	West Cajon	4,841	Peak, 2½ miles south	6,870	Crossed by trail at head of Cajon Creek.
72	34 21½	117 33	Cajon (main or central).	4,676	No marked peaks near; slopes westward gentle.		Summit of old Salt Lake wagon-road; altitude from Williamson's Pacific Railroad Reports.
73	34 20½	117 27	*East Cajon*	4,196	No marked peaks near		Summit of present wagon road from San Bernardino to Panamint.
74	34 19½	117 25½	Pass 2½ miles east of Fear's Station.	3,771	do		Trail between Fear's Station, Tejon Creek, and Holton Ranch (West Fork Mohave River).
75	34 14½	117 20	Devil's Cañon	4,683	Peak, 1½ miles west	5,509	Summit of road from San Bernardino.
76	34 13½	117 17	Waterman's	4,721	Strawberry Peak, 3 miles eastward.	6,014	Summit of trail head of Waterman's Cañon.
77	34 13½	117 12½	Strawberry	5,106	Strawberry Peak, 1½ miles westward.	6,014	Summit of road from San Bernardino to Little Bear Valley.
78	34 17	116 54	Holcomb Valley	7,131	Peak, 1½ miles south	8,132	At placer mines on summit of road west of Bear Valley.
79	34 17	116 50	Bear Valley	6,856	No marked peaks near		Summit of wagon-road about ½ mile north Bear Valley mining camp.

Material was obtained for Atlas sheets (entire) 47 A, 56 D, and 84, while large contributions were made to sheets 20 B and D, 29 A and C, 73, 90 A, and 78 A. (See Progress Map.)

Volume VI, Botany, appeared during this year, as also extract from Volume II, as "Field List of Time Stars," "List of Reports and Maps" (first edition). (See "List of Reports and Maps," second edition, 1881.)

The following regular topographic Atlas sheets were reproduced: 41 B, 61 C, 61 D, 62 A, 62 C, 69 B, 77 D, and the Land Classification sheets 41 B, 61 C, 62 A, 62 C, 69 B, and 69 D.

EXPEDITION OF 1879.

The expedition of this season was planned with the purpose of reviewing certain areas entered in 1873–'75–'77, and 78 in Atlas sheets 56 D, 61 B and 52 D, and for the completion of the Salt Lake survey and concluding of the special geological examination of the mountain range southward from the Spanish Peaks to the southern extremity of the Santa Fe Range.

Parties operating in Colorado, New Mexico, Utah, and California were obliged to leave the field on June 30 (the close of the fiscal year), no further funds being available for field expenditures.*

The basins of drainage within which are found the season's doings are the Rio Grande, Arkansas, Colorado of the West, Great Salt Lake, and Sacramento.

The principal streams, other than those indicated by the names of the basins, will be found on the Atlas sheet mentioned and in the description of maps, as also the result of observations of the various physical details. Each of the parties continued triangulation observations from all available points within the allotted area to the date of finally closing the field work. A large number of new mining camps in Colorado, as Silver Cliff, Leadville, Ten Mile, Carbonate, Frying Pan Gulch, and new discoveries on the Gunnison, were carefully located and given their appropriate places on the map.

The capacity of the several areas in relation to farming, stock raising, and timber supply will be pointed out in chapters on land classification and description of maps.

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* NOTE.—The route taken by the officer in charge, in connection with organization of parties and distribution of duties, was from Washington, D. C., to Ogden, via Pueblo, Colo.; thence to Antelope Island and other portions of Great Salt Lake and return; thence to Madera, the Yosemite region, and return; thence to Denver, Leadville, and South Park, in Colorado, including an ascent of Pike's Peak.

No mention is made, on the one hand, of the annual trips necessarily made, first from the San Francisco office, then that at Washington, and subsequently from the sub-field offices, to points of rendezvous; or, on the other, of detours made in the ascent of peaks, plateaux, and mesas, in the examination of passes, and for various and numerous other special objects. The kinds of travel were by rail, steamer, stage, ambulance, buckboard, mule and horse back, row-boat, and on foot.

No new routes of importance were developed, but profiles were made showing the connection between the head of the Arkansas and South Park with the eastern forks and tributaries of Grand River.

Other than the annual report there went to press during the year the MS. of Volume VII (Archæology), and the following Topographic Atlas sheets, viz: No. 32 D, 73 A, 78 A, and 84 B, were issued, as also Land Classification sheets 32 D, 61 D, 73 A, and 84 B. (See description of maps.)

The following special list of altitudes and condensed table of distances in and around Yosemite Valley have been kindly prepared by Lieut. M. M. Macomb, United States Artillery.

I.—SPECIAL LIST OF ALTITUDES OF POINTS OF INTEREST IN AND ABOUT THE YOSEMITE VALLEY.

Points of interest.	Altitudes.		Reference station.	Means of measurement.
	Above valley.	Above sea-level.		
I. PRINCIPAL WATERFALLS.	*Feet.*	*Feet.*		
Yosemite:				
Top of upper	2,548	6,482	U. B	T.
Pool foot of upper	1,046	4,980	U. B	T.
Top of lower	496	4,430	U. B	T.
Foot of lower	114	4,048	U. B	C.
Upper fall, 1,502 feet; lower fall and rapids, 496 feet; middle fall or cataract, 550 feet; total, 2,548 feet.				
Bridal Veil:				
Top	844	4,769	L. B	T.
Pool at foot	225	4,150	L. B	C.
Sheer fall, 619 feet; cascades and rapids, 225 feet; total, 844 feet.				

NOTE.—In order to determine a reliable altitude for some known and easily identified point in the bed of the valley, a barometric station was established near Barnard's, on a level with the Upper Iron Bridge over the Merced at that point, and a series of observations taken extending from October 4 to October 12, 1878. A second series extending from June 9 to June 12, 1879, afforded a check upon the first. Referring these to the synchronous observations of the Signal Service office at Sacramento (76.3 feet above sea), reducing by Williamson's formulæ and combining the results, gave 3,934.3 feet as a final value for the altitude above sea of the floor of the Upper Iron Bridge. In like manner independent sets of observations taken in the lower portion of the valley gave 3,924.6 feet for the floor of the Lower Iron or El Capitan Bridge.

Base lines measured in the vicinity of these two bench-marks afforded a number of good points of view from which, by angulation, data were secured for the altitudes of nearly all the important points in the walls of the valley, including Eagle Peak, Cloud's Rest, and others, from which it was possible to extend the work to peaks of the High Sierra.

It will be noted that these figures make the El Capitan Bridge only 9.7 feet below that at Barnard's. As the distance between the two bridges in a straight line is about 3.3 miles, it results that the average fall of the floor of the valley between these two points is only about three feet per mile. For lack of time and means no line of levels was run to check this result, but it cannot be greatly in error, as the current of the river between the points mentioned is sluggish, and no marked fall in the channel was noted until the El Capitan Bridge was reached. Here it was quite perceptible,

I.—SPECIAL LIST OF ALTITUDES OF POINTS OF INTEREST IN AND ABOUT THE YOSEMITE VALLEY—Continued.

Points of interest	Altitudes.		Reference station.	Means of measurement.
	Above valley.	Above sea-level.		
I. PRINCIPAL WATERFALLS—Continued.				
Ribbon (or Virgin's Tears):	*Feet.*	*Feet.*		
Top	3,081	7,006	L. B	T.
Pool at foot	1,449	5,374	L. B	C.
Sheer fall, 2,632 feet; cascades and rapids, 1,449 feet; total, 3,081 feet.				
Nevada:				
Top	1,987	5,921	U. B	C.
Pool at foot	1,370	5,304	U. B	C.
Height of fall, 617 feet.				
Vernal Fall:				
Top	1,131	5,065	U. B	C.
Pool at foot	795	4,729	U. B	C.
Height of fall, 336 feet.				
II. CLIFFS AND POINTS OF NORTH WALL OF VALLEY.				
El Capitan:				
Rounded summit	3,561	7,486	L. B	T.
South edge of cliff	3,087	7,012	L. B	T.

and for the same distance below it (3.3 miles) the average fall is about 128 feet per mile by barometric data. From the above it will be seen that the gently sloping floor of the valley lying between the above-mentioned bridges makes a natural plane of reference for the various cliffs, domes, and falls.

In the subjoined list the altitudes refer, in the case of peaks or domes, to the highest points or summits; in the case of cliffs, to some easily identified point at or near the edges; in the case of a waterfall, to the lip of the fall and to the pool at the foot of the cliff. As a rule the altitudes given are the results of independent angular measurements from two or more of the well-determined stations above referred to. In the case of points not well defined or not visible from such stations, barometric results are given. At the time of using the barometer for the measurement of falls, the stage of water was so low as to permit the observations to be taken at the lips of the falls and at the edges of the pools at their feet, thus making a close approximation to the true altitude possible.

Should *absolute values* for the altitudes of the floors of the bridges mentioned be obtained at any future time by means of levels of precision, it will be an easy matter to rectify the altitudes of all points in the list referred to them by applying the proper correction. The reference station is therefore noted in each case. In the mean time the barometric values above given may be taken with considerable confidence, as they accord closely with other authoritative results for the altitude of the floor of the valley. Colonel Williamson, in his Barometric Hypsometry, Part II, p. 28, gives 3,935 feet as the result of his computation of Miss Sproats' observations taken in October, 186–; and Professor Whitney gives 3,947.5 feet as the final result of several independent series of observations taken in 1867 and 1873. (See his Barometric Hypsometry, edition of 1874, p. 44.)

For convenience of reference the list has been subdivided as follows:

I. Principal Waterfalls.
II. Cliffs and Points of North Wall of Valley.
III. Cliffs and Points of South Wall of Valley.
IV. Domes and Peaks in the Vicinity of Valley.
V. Peaks of the High Sierra (from Tower Peak to the Merced Group).

Heights above sea as well as above the Yosemite are given. Under the heading "Reference station," U. B. stands for Upper Iron Bridge near Barnard's, and L. B. for Lower or El Capitan Bridge. Under the head of "Means of measurement," T stands for transit, C for cistern barometer, and A for aneroid.

1.—SPECIAL LIST OF ALTITUDES OF POINTS OF INTEREST IN AND ABOUT THE YOSEMITE VALLEY—Continued.

Points of interest.	Altitudes.		Reference station.	Means of measurement.
	Above valley.	Above sea-level.		
II. CLIFFS AND POINTS OF NORTH WALL OF VALLEY—Continued.				
El Capitan—Continued.	*Feet.*	*Feet.*		
Southeast corner of cliff	3,106	7,031	L. B	T.
West edge of cliff	3,127 to 3,350	7,068 to 7,284	L. B.	T.
Kai-al-au-wa:				
1. First point west of Ribbon Fall	3,212	7,147	L. B	T.
2. Second point west of Ribbon Fall	3,332	7,257	L. B	T.
3. Third point west of Ribbon Fall	2,723	6,648	L. B	T
Eagle Peak (highest of "Three Brothers")	3,817	7,751	U. B	T.
Middle Brother	2,776	6,710	U. B	T.
Lowest Brother	1,892	5,826	U. B	T.
Pom-pom-pe-sa (pyramidal rock southwest of Three Brothers)	696	4,630	U. B	T.
Columbia Rock (on Eagle Peak trail)	1,083	5,017	U. B	T.
Valley View Point (on Eagle Peak trail)	1,124	5,058	U. B	T.
Eagle Tower (point of cliff west of Eagle Peak trail)	3,228	7,162	U. B	T.
Yosemite Falls Flagstaff (on cliff west of fall)	2,894	6,828	U. B	T.
Lost Arrow, or Giant's Thumb (Granite Needle, near Yosemite Cliff)	2,846	6,780	U. B	T.
Yosemite Point (high cliff east of fall)	2,963	6,897	U. B	T.
Le-sam-ai-ti Cliff (east of Indian Cañon)	1,626	5,560	U. B	T.
Shade to Indian Baby Basket (west of Royal Arches)	1,518	5,452	U. B	T.
Washington Tower:				
Southeastern edge	1,675	5,609	U. B	T.
Southern edge	1,922	5,856	U. B	T.
III. CLIFFS AND POINTS OF SOUTH WALL OF VALLEY.				
Leaning Tower (south of Bridal Veil Fall)	1,905	5,830	L. B	T.
High Point (south of Leaning Tower)	3,288	7,213	L. B	T.
Cathedral Rocks (also called Three Sisters and Three Graces:)				
Lowest point	1,635	5,569	U. B	T.
Middle point	2,593	6,527	U. B	T.
Highest	2,697	6,631	U. B	T.
Cathedral Spires (highest)	2,000	5,934	U. B	T.
Cliffs southeast of Cathedral Rocks and south of Cathedral Spires:				
First	2,697	6,631	U. B	T.
Second	2,928	6,862	U. B	T.
High Spire south of Cathedral Bridge	2,884	6,818	U. B	T.
Profile (or Fissure) Cliff	3,500	7,425	L. B	T.
The Sentinel	3,071	7,005	U. B	T.
Union Point (rock)	2,356	6,290	U. B	T.
Glacier Point (jutting rock)	3,277	7,211	U. B	T.
Cliff southwest of Register Rock (opposite Grizzly Point)	2,489	6,423	U. B	T
Cascade Cliffs, Little Yosemite Valley:				
West Cliff		7,728	U. B	T.
East Cliff		6,966	U. B	T.
IV. DOMES AND PEAKS IN VICINITY OF VALLEY.				
South Dome (base of flagstaff at summit)	4,891	8,825	U. B	T.
Upper buttress to northward	4,165	8,110	U. B	T.
Lower buttress, or Awais Point	2,986	6,920	U. B	T.

I.—SPECIAL LIST OF ALTITUDES OF POINTS OF INTEREST IN AND ABOUT THE YOSEMITE VALLEY—Continued.

Points of interest.	Altitudes. *		Reference station.	Means of measurement.
	Above valley.	Above sea-level.		
IV. DOMES AND PEAKS IN VICINITY OF VALLEY—Continued.	*Feet.*	*Feet.*		
North Dome	3,591	7,525	U. B	T.
Basket or Mitre Dome ($\frac{7}{10}$ mile northeast of North Dome)	3,670	7,604	U. B	T.
Mount Watkins:				
Rounded summit, north	4,489	8,423	U. B	T.
Rounded summit, south	4,366	8,300	U. B	T.
Clouds' Rest:				
Summit	5,978	9,912	U. B	T.
First pinnacle, southwest		9,468	U. B	T.
Second pinnacle, southwest		9,467	U. B	T.
Bluff $\frac{6}{10}$ mile southward (west of Hopkins' meadow)		9,118	U. B	T.
Starr King:				
Main peak	5,146	9,080	U. B	T.
Dome $\frac{11}{16}$ mile northwest	4,637	8,571	U. B	T.
Dome $\frac{11}{16}$ mile southeast	4,893	8,827	U. B	T.
Dome $\frac{5}{8}$ mile southeast	4,661	8,595	U. B	T.
Cap of Liberty	3,128	7,062	U. B	T.
Mount Broderick	2,701	6,635	U. B	T.
Grizzly Point	2,273	6,207	U. B	T.
Sentinel Dome	4,188	8,122	U. B	T.
Ostrander's Rocks:				
North	4,208	8,142	U. B	T.
South	4,223	8,157	U. B	T.
Kai-al-au-wa Hill (head of Ribbon Fall Brook)	5,026	8,960	U. B	T.
V. PEAKS OF THE HIGH SIERRA FROM TOWER PEAK TO THE MERCED GROUP.				
Tower Peak (northern part of Tuolumne Basin)	7,785	11,719	U. B	T.
Matterhorn (one of the crags in Tuolumne divide at head of Twin Lake Cañon)	8,326	12,260	U. B	T.
Conness Peak	8,618	12,552	U. B	T.
Warren Peak	7,947	12,281	U. B	T.
Dana Peak	9,109	13,043	U. B	T.
Hoffmann Peak	6,900	10,834	U. B	T.
Ten-ai-ya Peak (south of Lake Ten-ai-ya)	6,870	10,804	U. B	T.
Cathedral Peak	6,986	10,920	U. B	T.
Echo Peak	7,250	11,184	U. B	T.
McClure Peak	9,041	12,975	U. B	T.
Lyell Peak	9,170	13,104	U. B	T.
Ritter Peak	9,196	13,130	U. B	T.
Minarets	8,262	12,196	U. B	T.
Clark Peak (northwest end of Merced Group)	7,578	11,512	U. B	T.
Gray Peak	7,620	11,554	U. B	T.
Red Peak	7,752	11,686	U. B	T.
Merced Peak (culminating point of Merced Group)	7,774	11,708	U. B	T.
PEAKS OF THE WHITE MOUNTAIN RANGE, NEAR CALIFORNIA AND NEVADA STATE LINE.				
McBride Peak (northern extremity of White Mountains, 38.55 miles eastward of Lyell Peak)	9,481	13,415	U. B	T.
White Mountain Peak (culminating point of White Mountains, 38.23 miles eastward of Lyell Peak	10,311	14,245	U. B	T.

II.—CONDENSED TABLE OF DISTANCES FROM BARNARD'S, AT THE UPPER IRON BRIDGE, TO VARIOUS POINTS IN THE YOSEMITE VALLEY AND ITS VICINITY.

NOTE.—The subjoined list of distances to various places upon the principal roads and trails presents in a condensed form information of interest and value to visitors to the Yosemite Valley, as well as to permanent residents. The distances are based upon odometric measurements taken by parties of the Survey in 1878-'79, when all the important roads and trails were meandered.

Through the courtesy of Mr. J. M. Hutchings, when guardian of the Valley, bearings and distances were furnished which gave the location upon the map of the more recently constructed pieces of road, known as Meadow Avenue, Tisseyak Avenue, and Pohono Avenue, also of a number of new bridges. The distances, as given in the list, are over roads and trails which will be in use for years. Several new trails are now (1886) completed or in course of construction; notably a route from Glacier Point to top of Nevada Fall via the Tululawiak (or South Branch) Fall; Anderson's new trail to Vernal Fall via the north bank of the Merced; and a trail from the Yosemite Fall to and down Indian Cañon; but for these this office has no data. Barnard's, at the Upper Iron Bridge, has been taken as an initial point on account of its central location, towards which all the principal roads converge.

TABLE OF DISTANCES.

Names of points.	Distances from Barnard's.	Altitudes.	
		Above valley.	Above sea-level.
	Miles.	Feet.	Feet.
From Barnard's to—			
Artist Point, Madera Road	5.86	725	4,659
Bridal Veil Fall, Madera Road, opposite to	4.04		
Black Springs, Coulterville Road:			
via Meadow Avenue and Yosemite Bridge	4.96		
via Cook's and Folsom Bridge	4.61		
via South Road and El Capitan Bridge	4.70		
Cascade Falls, Coulterville Road:			
via Meadow Avenue and Yosemite Bridge	8.00		3,[illegible]
via Cook's and Folsom Bridge	7.75		
via South Road and El Capitan Bridge	7.84		
Cathedral Spires Bridge, northeast Cathedral Spires, on South Road	2.44		
Chalybeate Spring, Mirror Lake Road	2.45		
Columbia Rock, Eagle Peak Trail	1.86	1,083	5,017
Cook's Hotel	0.77		
Clouds' Rest, summit via old trail to Register Rock	11.83	5,978	9,912
Eagle Meadow, Eagle Peak Trail	5.46	3,137	7,071
Eagle Peak (summit)	6.26	3,817	7,751
El Capitan Bridge (opposite to) via South Road	2.68		3,[illegible]
Folsom Bridge	1.50		3,[illegible]
Forks Coulterville and Big Oak Flat Roads, north of El Capitan Bridge:			
via Cook's and Folsom Bridge	3.74		3,[illegible]
via Meadow Avenue and Yosemite Bridge	3.90		
via South Road and El Capitan Bridge	2.83		
Glacier Point, by trail	4.45	3,277	7,211
Harris'	1.15		
Hopkins' Meadow, Clouds'-Rest Trail via old trail to Snow's	9.30		
Indian Camp, west of Folsom Bridge:			
via Leidig's	1.50		
via Meadow Avenue	1.04		
Indian Cañon Bridge	0.65		
Leidig's Hotel	1.07		
Lyell Peak, by trail	28.30	9,170	13,104
Lyell Camp, head of Tuolumne Meadows on Lyell Creek	22.56	5,084	9,018

TABLE OF DISTANCES.

Names of points.	Distance from Bernard's.	Altitudes.	
		Above valley.	Above sea-level.
From Bernard's to—	*Miles.*	*Feet.*	*Feet.*
Mirror Lake:			
via Meadow Avenue	2.88	163	4,096
via Tisseyak Avenue	3.67	....	....
New "Inspiration Point," Madera Road	7.34	1,449	5,383
Nevada Falls (top) via old trail to Snow's	5.45	1,987	5,921
Pohono Bridge:			
via Meadow Avenue and North Road	5.40	....	....
via Folsom Bridge	5.15	....	....
via South Road and Bridal Veil Falls	5.17	....	....
River View via Folsom Bridge and North Road	4.06	....	....
Register Rock (in Cañon of Merced, on old trail to Snow's)	3.25	577	4,511
Rocky Point (at foot of "Three Brothers," on North Road)	1.44	....	....
Sentinel Dome summit	5.57	4,189	8,123
Snow's Casa Nevada Inn, via old trail	4.64	1,355	5,289
South Dome, top, via old trail to Snow's	10.00	4,889	8,823
Tenaiya Bridge (over Tenaiya Creek, south of Washington Tower)	2.20	....	....
Tisseyak Bridge (over Merced River, south end Tisseyak Avenue)	2.06	....	....
Tululawiak Bridge	2.60	....	4,184
Union Point	3.13	2,356	6,290
Valley View (or Transport) Point	2.42	1,124	5,058
Vernal Fall, foot of, via old trail to Register Rock	3.50	795	4,729
Yosemite Bridge	0.46	....	....
Falls (top of upper, at Flagstaff)	4.19	2,594	6,528
Falls (foot of upper)	2.65	1,046	4,980
Falls (foot of lower) by road	0.88	114	4,048

ROUND TRIPS.

From Bernard's—	Miles.
To Mirror Lake via Meadow Avenue and return via Tisseyak Avenue	6.58
Through Tisseyak Avenue and return, omitting Mirror Lake	5.11
To Pohono Bridge via Meadow Avenue and North Road, and return via South Road	10.57
Grand circuit of the Valley via Meadow, Tisseyak, and Pohono Avenues	15.28
The same, including Mirror Lake and Cascade Falls	22.46

The study of the Laramie in the Trinidad coal fields has led to a very important contribution of much economic interest by Professor Stevenson, showing the continuity of the Laramie coal beds, proving to this extent their general resemblance to the coal beds of the Carboniferous strata or age.

COLLECTIONS.

The only natural history collections of the year were made by Professor Stevenson in the mountain region east of the Rio Grande and between the latitudes of Fort Garland and Santa Fe, and consisted of a number of invertebrate fossils and fossil plants and specimens from 26 distinct coal beds. The topographic results of the season are found on published sheets Nos. 52 D, 56 B and D, 61 B and D, and 62 A and C, and also on the original platting sheet of the Great Salt Lake and vicinity.

FINAL SUMMARY.

Although this work was projected simply as a first survey during the initial stages of settlement of the region penetrated, looking to a resultant topographic map, to be speedily available for military administration and operations as its primal object, the whole limited in means, men, time, and money, nevertheless, there has been an outcome also from other fields of observation, among the total of all of which the following may be briefly summarized:

	Square miles.
Total area west of one hundredth meridian (see progress and annual reports and rectangle map accompanying Appendix E)	1,443,360
Mountainous portion of same west of the Great Plains (approximately)	993,360
Surveyed topographically of above mountain area	*359,065
Topographic maps of same, published in 50 atlas sheets (each 19 by 24 inches), on scales of 1″ = 8 m., or 1:506,880; 1″ = 4 m., or 1:253,440; 1″ = 2 m., or 1:126,720; 1″ = 1 m., or 1:63,360; 1″ = ⅔ m., or 1:42,240	326,891
Part of above area surveyed, but not issued in regular atlas sheet form (original data reduced upon partially completed plotting sheets)	32,174
Regular topographic atlas sheets of above scales issued (19 by 24 inches)	50
Regular land classification atlas sheets issued (19 by 24 inches), (embracing 134,653 square miles)	30
Regular geological atlas sheets issued (19 by 24 inches) (embracing 129,841 square miles)	11
Special and miscellaneous maps issued (various sizes and scales) (not accompanying reports)	19
Special maps issued (various sizes and scales) (accompanying reports)	54
Total maps of all kinds issued	164
Total number of publications of all kinds issued (15 quarto, 12 annual reports, 14 special and miscellaneous)	41

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*NOTE.—Field-plats for all of above are in contours, while final published maps are both in hachures and contours.

GENERAL GEOGRAPHICAL RESULTS.

Observations and delineation of the physical details of 143 mountain ranges, 103 groups of mountains, and 36 plateaux, within the limits surveyed topographically, from among 161 ranges, 196 mountain groups, and 41 plateaux for the entire western mountainous area.

Discovery and naming of the great Colorado Plateau in 1869 and 1871.

Securing the principal part of the data necessary to a final classification of the mountain and plateau systems of the western mountain region.

Topography of 124,300 square miles of the Great Interior Basin (total area, 208,600 square miles) secured, and 1,925 out of 2,775 miles of its perimeter traced and definitely located, including its northwestern and southwestern portions.

The position and general profile determined of 840 miles of the Continental Divide.

Special exploration of the Colorado of the West to the head of navigation, and its Grand Cañon to the mouth of Diamond Creek.

Determination of the limits and extent of the Great Interior Basin, including Death Valley, the Amargosa Desert, and the Colorado and Mohave River Basins.

Special examination of the Colorado River of the West, from Stone's Ferry to Fort Yuma, with a view to its diversion for purposes of irrigation.

Specially accurate topographic surveys of Lake Tahoe and vicinity and Yosemite Valley (including much hypsometric detail) and its approaches (see special maps). Special typical contour Survey of the Washoe mining region.

Determination of passes of western, northwestern, and southwestern rim of the Great Interior Basin and of the Continental Divide from fortieth parallel north latitude to Mexican boundary.

Preliminary location of southern portion of eastern boundary between Nevada and Utah in 1869.

Preliminary exploration of north and south railroad lines crossing the Colorado River at the mouth of the Virgin River and at foot of the Grand Cañon.

Location and extent of great forests in Eastern Arizona and Western New Mexico.

Determination of heights of 395 peaks (with names, many of which are new) above 10,000 feet, and of 754 others (with names) between 5,000 and 10,000 feet in height.

Location and profile of 202 mountain passes (26 of same belonging to the Continental Divide, and 79 to the western rim of the Great Interior Basin), and meander of not less than 90 rivers and thousands of minor streams.

Exploration and underground measurement of 4 caves in Nevada and New Mexico.

Meander of 21 lakes (including Great Salt Lake).

Exploration of the Grand Cañon of the Colorado, the Cañon de Chelle, and others, also surveys about the Great American Falls of Snake River.

Discovery of north and south routes, especially from California, Nevada, Utah, Wyoming, and Colorado to Arizona and New Mexico, also from California and Nevada to the Valley of the Columbia.

Discovery and measurement of levels below sea with determination of limits of special Death Valley Basin.

Determination of non-existence of "Preuss Lake," found on current maps of 1869, along eastern boundary of Nevada.

Determination of evaporation about Great Salt Lake.

Measurement of volumes of 7 principal streams with reference to water supply and irrigation.

Observations for land classification for an area of approximately 175,000 square miles.

Topography and partial land classification of 33 Indian (including 19 pueblos) and 32 military reservations, with geographic co ordinates of seven others.

Landscape and stereoscopic photographs of mountain forms and Colorado Cañon and other physical details.

Connection made with all land survey stakes wherever found, with results permanently recorded on unpublished plotting sheets.

Invention and introduction of the modified secant conic projection, accomplishing a minimum of distortion in azimuth and distance, and the conjoining of sheets.

The introduction and development of land classification, commencing in 1872 (see Chapter V.)

Fifteen regular atlas sheets issued (1″ = 8 m.), embracing 261,232 square miles; thirty-four quarter atlas sheets (1′ = 4 m.), embracing 146,026 square miles; one subquarter atlas sheet (1″ = 2 m.): also Colorado Cañon map, scale 1″ = 6 m.; of Lake Tahoe region 1″ = ⅔ ms.; Yosemite 2′ = 1 m.; and of the Washoe district, scale 1″ = 1,500 feet, the three latter as special types.

Contributions to the theory and practice of the determination of field astronomic latitudes and longitudes and barometric hypsometry appear in Vol. II, quarto series.

Published latitudes and longitudes (other than those contained in this volume) found in part in Vol. II, Astronomy.—Ast. Report, 1874—Preliminary Report of 1869.—Distances, &c., 4°, 1872—Special Volume, royal 8 vo., and Annual Reports of 1875–'76–'77–'78–'79 and '80.

Vertical limits of timber on various mountain ranges ascertained.

Invention of apparatus for determining absolute personal equation (see p. 475, Vol. II).

Improvements in the portability, telescopic, and microscopic power of triangulation instruments.

Determination of the mean declination for 1875 of 2,018 stars.

The preparation, issue, and use of special forms (45 in number) for astronomic, geodetic, trigonometric, barometric, topographic, and other observations and their reduction.

A trigonometric basis for the Survey with initial points measured and developed bases was established in 1873.

Hourly barometric observations at many reference stations made and reduced.

Determination of altitudes, reports upon, published in part in Vol. II, special volume royal 8vo, and Annual Reports for 1875–'76–'77–'78–'79 and '80.

Geological reconnaissance of an area of not less than 221,500 square miles.

Determination of the extent and correlation of the geological formations for the above with new geological facts and conclusions; of the existence of fossil remains widely distributed; and of glacial and volcanic action and phenomena.

Determination of the limits in area within which the search for the precious metals may be successful.

Special contributions to the origin and building of mountains, the structure and age of ranges, to glaciation, the existence of precious and economic minerals, opportunities for artesian wells, also to economic geology, age of coals, distribution of lava, and the presence of borates at new localities east of the Sierra Nevada in the Great Basin.

Special chapters relating to the geological phenomena found upon the Colorado Plateau, in the Grand Cañon of the Colorado, the Basin Ranges, the Cordilleras, the Sierra Madre, and San Juan Ranges of the Rocky Mountain systems, &c.

Not less than fifty thermal and mineral springs discovered, of which twenty-seven were analyzed.

Old "Lake Bonneville" outlined and partially investigated.

Location and examination of 219 mining districts.

One new mineral substance discovered, analyzed, and named.

Not less than 31 *new* species of vertebrates from the Loup Fork and many others from the Eocene, and 63 of invertebrates discovered, described, and their geological and other relations established.*

In zoology, from the very large and rare collection of birds only one was of a new species, while of reptiles there were eight, fishes thirty-two, mollusca one, and insects sixty-four, from the extremely valuable and rich collections, with many specimens of species exceedingly rare, though not new.†

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* The identification and description of these new species by Prof. E. D. Cope and Dr. C. A. White may be found in Vol. IV, quarto reports, and Appendix to Vol. III (Supplement), Geology.

† Messrs. Yarrow and Henshaw have kindly prepared the following list of new species in zoology:

BIRDS.

Aphelocoma insularis Henshaw. Santa Cruz Island, Cal., 1875. H. W. Henshaw.

REPTILES.

Bufo pictus Cope. Utah, 1872.
Spea stagnalis Cope. Utah and New Mexico, 1874.
Rana onca Cope. Utah, 1872. H. C. Yarrow.
Chilopoma rufipunctatum Cope. Southern Arizona, 1874. H. W. Henshaw.
Eutænia plutonius Yarrow. Arizona, 1871.
Sceloporus jarrovii Cope. Southern Arizona, 1874. H. W. Henshaw.
Sceloporus tristichus Cope. New Mexico, 1874. W. G. Shedd.
Sceloporus smaragdinus Cope. Utah and Nevada, 1872. H. C. Yarrow.

In Volume VI (Botany) is found the enumeration or description of 104 orders, 637 genera, and 1,657 species from the Survey collections, and not a few of which are new.

FISHES.

Plagopterus argentissimus Cope. San Luis Val., Col., 1872.
Lepidomeda vittata Cope. Col. Chiquito River, Ariz., 1873.
Lepidomeda jarrovii Cope. Col. Chiquito River, Ariz., 1873. H. W. Henshaw.
Apocope henshavii Cope. Provo, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Apocope couesii Yarrow. Camp Apache, Arizona, 1873. H. W. Henshaw.
Apocope ventricosa Cope. Arizona and New Mexico, 1873. H. W. Henshaw.
Alburnellus simus Cope. San Ildefonso, N. Mex., 1874. E. D. Cope and H. C. Yarrow.
Alburnellus jemezanus Cope. San Ildefonso, N. Mex., 1874. E. D. Cope and H. C. Yarrow.
Ceratichthys physignathus Cope. Arkansas River at Pueblo, 1874. C. E. Aiken.
Ceratichthys sterictus Cope. San Ildefonso, N. Mex., 1874. E. D. Cope and H. C. Yarrow.
Hypsilepis iris Cope. San Ildefonso, N. Mex., 1874. E. D. Cope and H. C. Yarrow.
Hybopsis timpanogensis Cope. Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Gila phlegethontis Cope. Beaver River, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Gila tænia Cope. Provo River, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Gila ardesiaca Cope.
Gila gula Cope. New Mexico, 1874. H. W. Henshaw.
Gila nigra Cope. Arizona, 1874. H. W. Henshaw and J. T. Rothrock.
Gila seminuda Cope and Yarrow. Southern Utah, 1872. H. C. Yarrow.
Siboma atraria var. *longiceps*, Cope. Utah, 1872. H. C. Yarrow.
Myloleucus parovanus Cope. Beaver River, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Hyborhynchus siderius Cope. Camp Lowell, Ariz., 1874. J. M. Rutter.
Hyborhynchus nigellus Cope. Pueblo, Colo., 1874. C. E. Aiken.
Campostoma aikenii Cope. Pueblo, Colo., 1874. C. E. Aiken.
Pantosteus platyrhynchus Cope. Provo River, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Pantosteus jarrovii Cope. New Mexico, 1873. H. W. Henshaw and H. C. Yarrow.
Pantosteus virescens Cope. Pueblo, Colo., 1874. C. E. Aiken.
Catostomus alticolus Cope. Twin Lakes, Colo., 1873. J. T. Rothrock.
Catostomus fecundus Cope and Yarrow. Utah Lake, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Moxostoma trisignatum Cope. Pueblo, Colo., 1874. C. E. Aiken.
Haplochilus floripinnis Cope. Colorado, 1873. H. W. Henshaw and J. M. Keasby.
Uranidea wheeleri Cope. Beaver River, Utah, 1872. H. C. Yarrow and H. W. Henshaw.
Syllaemus latifrons (fossil) Cope. Colorado, 1874. W. L. Marshall.

INSECTS.

Trogus melleus Cresson. New Mexico, 1874. T. V. Brown.
Agama vitida Cresson. Colorado, 1873. C. W. Whipple.
Agama albipes Cresson. Nevada, 1872. H. C. Yarrow.
Myzine frontalis Cresson. New Mexico, 1874. H. C. Yarrow.
Ammophila yarrowi Cresson. Pueblo, Colo., 1874. H. C. Yarrow.
Stizus nevadensis Cresson. Nevada, 1872. H. C. Yarrow.
Eumenes coloradensis Cresson. Colorado and New Mexico, 1874. H. C. Yarrow.
Vespa occidentalis Cresson. Nevada, 1872, H. C. Yarrow. New Mexico, 1873, H. W. Henshaw.
Halictus trizonatus Cresson. Nevada, 1872. H. C. Yarrow.
Agapostemon meliventris Cresson. Colorado, 1872. H. C. Yarrow.
Nomia nevadensis Cresson. Nevada, 1872. H. C. Yarrow.
[illegible] marginipennis Cresson. Colorado and New Mexico, 1874. H. C. Yarrow
Megacilissa yarrowi Cresson. New Mexico, 1874. H. C. Yarrow.
Melecta thoracica Cresson. Eastern Nevada, 1872. H. C. Yarrow.
Melissodes nevadensis Cresson. Nevada, 1872. H. C. Yarrow.

It contains also contributions to economic botany and geographical distribution of vegetable life.

Bombus nevadensis Cresson. Eastern Nevada, 1872. H. C. Yarrow.
Aphaenogaster sp. nov., Camp Hill, 1874. J. H. Rutter.
Lithurgis apicalis Edw. Colorado and New Mexico. H. C. Yarrow and C. E. Aiken.
Nomada grandis Edw. Colorado. H. C. Yarrow.
Argynnis hesperis Edw. Colorado.
Argynnis nitocris Edw. White Mountains, Ariz., 1873. H. W. Henshaw.
Argynnis nokomis Edw. Arizona, 1871.
Argynnis nausicaa Edw. Rocky Cañon, Ariz., 1874. H. W. Henshaw.
Synchloe crocale Edw. White Mountains, Ariz., 1873. H. W. Henshaw.
Gyrocheilus tritonia Edw. White Mountains, Ariz., 1873. H. W. Henshaw
Apatura leilia Edw. Camp Lowell, Ariz., 1874. H. W. Henshaw.
Satyrus wheeleri Edw. Arizona, 1873.
Thecla siva Edw. Fort Wingate, N. Mex., 1874. H. W. Henshaw
Lycaena melissa Edw. Colorado, 1871.
Lemonias cythera Edw. Arizona, 1873. H. W. Henshaw.
Catocala editha Edw. Sonoita Valley, Ariz., 1874. H. W. Henshaw.
Euchaetes elegans Stretch. Owen's Valley, Cal.
Leucarctia albida Stretch. Owen's Valley, Colo., 1875. H. W. Henshaw.
Arctia docta var. *arizonensis* Stretch. Arizona.
Arctia yarrowii Stretch. Arizona.
Lasia klettii Osten-Sacken. Camp Apache, Ariz., 1873. F. Klett.
Bembidium nevadensis Ulke. Nevada.
Dasytes ruficollis Ulke. Nevada.
Epicauta wheeleri Ulke. Arizona.
Lytta lugubris Ulke. Owen's Valley, Cal.
Crossidius intermedius Ulke.
Lioderma viridicata Uhler. Colorado. J. T. Rothrock.
Scolopocerus secundarius Uhler. Gila River, Arizona. O. Loew
Megalonotus sodalicius Uhler. Colorado, Nevada, Oregon.
Miris instabilis Uhler. Colorado. J. T. Rothrock.
Hadronema militaris Uhler.
Calocoris superbus Uhler. California. F. Bischoff.
Corisa dispersa Uhler. California. F. Bischoff.
Mantis wheeleri Thomas.
Pedioscirtetes nevadensis Thomas.
Syrbula fusco-vittata Thomas. Lower Arizona, 1874. H. W. Henshaw.
Oedipoda hoffmanni Thomas. Arizona, 1871. W. J. Hoffman.
Oedipoda wheelerii Thomas.
Oedipoda utahensis Thomas. Utah.
Oedipoda sparsa Thomas. New Mexico.
Eremobia magna Thomas. Lower Arizona, 1874. H. W. Henshaw.
Pezotettix oregonensis Thomas. Oregon. J. Haldeman.
Pezotettix marshallii Thomas. Southern Colorado.
Pezotettix humphreysii Thomas. Southern Arizona, 1874.
Caloptenus yarrowii Thomas.
Acridium shoshone Thomas. Nevada, Arizona.
Acridium albolineatum Thomas. Arizona? 1873.
Steiroxys hermanii Thomas. 1873.
Steiroxys bilineata Thomas. San Carlos, 1874. H. W. Henshaw.

MOLLUSCA.

Anodonta dejecta Lewis. Arkansas River, west of one hundredth meridian. H. C. Yarrow.

The numerous archæological and ethnological collections from vicinity of Santa Barbara, California, from Pueblos in Arizona and New Mexico, and certain interior tribes, are mentioned and described in Volume VII of the quarto series, which contains also notes upon human crania and skeletons and 40 vocabularies of languages and dialects of as many nomad and village tribes.

The following is a list of the various lots and specimens forwarded by this office through the Smithsonian Institution to the National Museum, their practical importance to the Survey having ceased with the examination and reports made thereupon. This list has been compiled from the records of this office and those of the Smithsonian Institution so far as the latter have been available:

Subject.	F. Y., 1871.	F. Y., 1872.	F. Y., 1873.	F. Y., 1874.	F. Y., 1875.	F. Y., 1876.	F. Y., 1877.	F. Y., 1878.	F. Y., 1879.	F. Y., 1880.	F. Y., 1883.	F. Y., 1884.	Total.
Rocks:													
Specimens								2,494	1,921				4,415
Boxes or lots									9		2	2	13
Minerals, ores, &c.:													
Specimens								1,993	1,613				3,606
Vertebrate fossils:													
Specimens					500				*500				1,000
Lots or boxes					1				8				9
Invertebrate fossils:													
Lots										10			10
Specimens	120	1,426	1,506	250				2,150	1,100				6,627
Mammals:													
Specimens	9	21	135	53	43	10		16					285
Birds and mammals (alcoholic):													
Specimens					26	4							30
Mammal crania:													
Specimens			37	3	18	2							60
Birds:													
Specimens	60	622	689	1,025	793	150		261	470			31	4,101
Birds' nests:													
Specimens		10	20	6				19					56
Birds' eggs:													
Specimens	12	30	183	11	14			738					988
Birds' crania (sterna, &c.):													
Specimens		4	31	22	9	2							68
Birds' skeletons:													
Specimens			4										4
Bird-embryos:													
Specimens					5								5
Reptiles (batrachians):													
Specimens	135	550	950	750	750	83			12				3,230
Lots	27	100	192	140	103	8		45	2	3			620
Fishes:													
Specimens	15	275	850	650	900	850		400	16	1			3,957
Lots	8	48	100	91	116	49		25	2	3			455

Subject.	F. Y., 1871.	F. Y., 1872.	F. Y., 1873.	F. Y., 1874.	F. Y., 1875.	F. Y., 1876.	F. Y., 1877.	F. Y., 1878.	F. Y., 1879.	F. Y., 1880.	F. Y., 1883.	F. Y., 1884.	Total.
Coleoptera (beetles):													
Specimens	1,300	160	4,500	4,200	1,200	2,000	......	......	......	......	......	......	13,360
Lots	126	5	260	211	16	24	......	......	......	......	......	......	642
Orthoptera (grasshoppers):													
Specimens	......	......	500	......	......	......	......	600	......	......	......	......	1,100
Lots	......	......	46	......	......	......	......	18	......	......	......	......	64
Lepidoptera (butterflies):													
Specimens	......	......	308	......	463	......	......	......	......	......	......	......	771
Lots	......	......	144	......	162	......	......	......	......	......	......	......	306
Hemiptera:													
Specimens	......	......	......	......	......	......	......	3	......	......	......	......	3
Lots	......	......	......	......	......	......	......	1	......	......	......	......	1
Diptera and Neuroptera (flies):													
Specimens	......	......	30	......	......	......	......	......	......	......	......	......	30
Lots	......	......	13	......	......	......	......	......	......	......	......	......	13
Hymenoptera (bees and wasps):													
Specimens	......	......	450	......	790	50	......	1	......	......	......	......	1,291
Lots	......	......	38	......	......	8	......	2	......	......	......	......	48
Arachnida (spiders):													
Specimens	......	......	250	......	100	......	......	......	......	......	......	......	350
Lots	......	......	26	......	16	......	......	......	......	......	......	......	42
Mollusca (shells):													
Specimens	......	......	600	250	1,000	150	......	80	......	......	......	......	2,080
Lots	......	......	86	25	95	15	......	22	......	12	1	......	256
Crustacea:													
Specimens	......	......	......	......	100	200	......	12	9	......	......	......	321
Lots	......	......	......	......	1	14	......	1	13	......	......	......	29
Botanical:													
Specimens	......	......	......	......	......	*11,000	2,160	106	......	......	......	......	13,266
Lots	......	......	......	......	......	......	......	2	......	......	......	......	2
Diatomaceous earth:													
Lots	......	......	......	......	......	......	......	11	......	......	......	......	11
Ethnological:													
Specimens	......	......	......	......	......	......	300	......	......	......	......	......	300
Archæological:													
Lots or boxes	......	......	......	......	......	......	......	......	......	......	6	......	6
Specimens	......	......	......	......	......	......	......	......	26	719	......	......	745
Total specimens	1,657	2,368	11,869	7,340	6,631	14,001	2,460	9,096	5,667	719	......	31	61,[illegible]
Total lots	185	182	861	465	362	125	......	149	36	27	7	2	2,[illegible]

* Approximated.

NOTE.—The collection of rocks, minerals, ores, &c., comprising more than four thousand specimens from various localities in the West, as mentioned in the summarized list in the Annual Report for 1879 as having been forwarded to the Smithsonian Institution, was, at my request, donated to the museum at the West Point Military Academy for use and exhibition there. The botanical specimens have all been finally deposited in the Agricultural Bureau. Various crania and skeletons were from time to time forwarded to the Army Medical Museum.

A reference to the collections made will be found in the following Annual Reports: 1873, pp. 8 and 9; 1874, pp. 105-109; 1875, pp. 186, 187, 188; 1878, p. 91, and 1879, p. 198; and to those transferred to the Smithsonian and National Museum as follows: 1877, p. 1248; 1878, p. 92; 1879, pp. 198 and 199; and 1880, p. 36.

Latitudes, longitudes, altitudes, and topographic details have been furnished for the use of the Government in the compilation of the new western territory, and United States maps by the Engineer Department, and special maps prepared and compiled by engineer officers at headquarters, military division, and department, by the General Land Office, the Post-Office Department, the Coast and Geologic Surveys; also to 18 publishing houses and private map publishers in America and Europe.

Independent of the maps, the main body of the information is found in nine principal volumes (8 quarto and 1 royal octavo). Mention is made in the list of contributors to the quarto volumes, in the various reports and upon the resultant maps, of those assistants and others through whose zeal and industry so full and complete results have, in the main, been attainable.

The whole points a permanent contribution to the geography, topography, and natural history of 359,065 square miles of the western portion of the United States.

CHAPTER II.

ITINERARY OF COLORADO GRAND CAÑON AND RIVER TRIP OF 1871.

EXPLORATIONS OF THE COLORADO RIVER OF THE WEST.

A brief chronological account of the earlier explorations prior to the commencement of the 19th century, and of subsequent exploring and surveying trips, is not thought to be out of place as a preface to the present report upon further exploration of the river from the direction of its mouth toward its source, made by parties of the expedition of 1871.

An epitome of the statements contained in the report of Lieutenant Ives concerning the early explorations of the river, which doubtless were gathered by searching among many authentic records, are given herewith.

> Very little has been known concerning this river. Two streams, Green and Grand rivers, which flow through Utah in a southerly direction, have been supposed to unite somewhere near the southern boundary of that Territory and form the Colorado, but the point of junction has never been visited nor determined.
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> * * * * * * *
>
> In less than fifty years after the landing of Columbus, Spanish missionaries and soldiers were traveling upon the Colorado, following its course for a long way from the mouth, and even attaining one of the most distant and inaccessible points of its upper waters. More information was gained concerning it at that time than was acquired during the three subsequent centuries.
>
> In the year 1540 the viceroy of New Spain, interested in the accounts derived from a Franciscan monk of the latter's travels in the Territory now called New Mexico, sent an exploring expedition into that region under the command of Vasquez de Coronado. A detachment of twenty-five men, led by one Dias, left Coronado's party and traveled westward. He discovered the Colorado and followed it to its mouth.
>
> * * * * * * *
>
> About the same time Captain Fernando Alarçon, by order of the viceroy, sailed up the Gulf of California and ascended the Colorado in boats for a long distance.
>
> * * * * * * *

Another of Coronado's captains named Cárdenas, with a party of twelve men, reached the pueblos of Moquis, and repaired from them, with Indian guides, to a portion of the Colorado far distant from that seen by the others. The history states that after twenty days' march over a desert, they arrived at a river the banks of which were so high that they seemed to be three or four leagues in the air.

* * * * * * *

They averred that some rocks, which appeared from above to be the height of a man, were higher than the tower of the Cathedral of Seville. This was the first description of the famous Big Cañon of the Colorado.

Several times during the succeeding two centuries the lower part of the river was visited by Catholic priests. In 1744 a Jesuit missionary, named Jacob Sedelmayer, went thither, following the course of the Gila, and traveled extensively in both New Mexico and Sonora, and about thirty years afterwards the Jesuits established missions among the Yuma Indians, who live at the junction of the Gila and Colorado.

In 1776 another Catholic missionary, Father Escalante, traveled from Santa Fe to Utah, and having explored the region south of the Great Salt Lake, pursued a southwesterly course towards the sources of the Virgin, and then crossed to the Colorado, which he reached at a point that appears to have been almost identical with that attained from the opposite direction by Cárdenas more than two centuries before.

From this time the river was scarcely approached, excepting by an occasional trapper or some overland party crossing the lower portion *en route* to California. A considerable part of the emigration induced by the gold discoveries in that region passed through New Mexico by way of the Gila, and the travelers were subjected to molestation from the Yumas. In 1850 a detachment of troops was sent to the mouth of the Gila to keep these Indians under control, and not long afterwards a military post, called Fort Yuma, was regularly established.

The difficulty of furnishing supplies to the garrison across the desert was such that in the winter of 1850 and 1851 General Smith, commanding the Pacific Division, sent a schooner from San Francisco to the head of the Gulf of California, and directed Lieutenant Derby, Topographical Engineers, to make a reconnaissance with a view of establishing a route of supply to Fort Yuma via the Gulf and the Colorado. The result of the reconnaissance was successful and the route was at once put in operation.

* * * * * * *

In 1851 Captain Sitgreaves, Topographical Engineers, with a party of fifty individuals, made an exploration from Zuñi westward. He struck the Colorado at a point about 160 miles above Fort Yuma, and followed the east side of the river, keeping as near to the bank as possible, to the fort.

* * * * * * *

In the spring of 1854 Lieutenant Whipple, Topographical Engineers, in command of an expedition for the exploration and survey of a railroad route near the 35th parallel, reached the Colorado at the mouth of Bill William's Fork, and ascended the river about 50 miles, leaving it at a point not far below where Captain Sitgreaves had first touched it.

* * * * * * *

The course of the Colorado northward could be followed with the eye for only a short distance, on account of mountain spurs that crossed the valley and intercepted the view. A high, distant range, through which the river apparently broke, was supposed to be the mouth of the "Big Cañon," which the Spaniards in 1540 had visited at a place far above.

The visits of exploratory parties and other trips made prior to the year 1857, and not mentioned by Lieutenant Ives, are as follows:

Capt. Francisco de Ulloa, who, in September, 1539, coasted the Gulf of California, found the waters turbid from the effects of a strong current and suspected that he was near the mouth of a great river. The position of such a river was accordingly indicated on a sketch map by the pilot.

Gov. Juan de Oñate in 1604 went from New Mexico with two priests and thirty soldiers to Moqui and thence crossed the country southwestwardly to the Santa Maria (Bill Williams Fork), which was followed to the Colorado. He used the name Colorado, but applied it to the branch since known as Colorado Chiquito, not suspecting any connection between it and the great river which he found to the westward and named Rio Grande de la Esperanza. Members of his party ascended the river for some distance, and he afterwards followed it to the mouth, noting the Gila and naming it Rio de Jesus.

Father Kino, who, prior to the year 1700 (making a final trip in 1702), explored a part of California, crossing it from the east to the west on the 26th degree of latitude, from Loreto to New Year's Harbor, following the Rio San Tomas, now the Rio de la Purissima, and the Boca de la Purissima. (See Annual Report U. S. Geographical Surveys, 1878, accompanied by map, p. 228.)

Father Garces, a Carmelite friar, made a journey in 1775 from Sonora through the Colorado River country, thereby opening another line of communication to the interior, extending as far as the Southern Sierra Nevada.

Father Font, in his visit to portions of the Great Basin System in 1777, crossed the Colorado at the Mohave Valleys and proceeded to the eastward as far as the Moquis Villages.

A copy of the map accompanying the journal of Father Font was procured in California by the late Brevet Maj. Gen. E. O. C. Ord, United States Army, then a captain, and is on file in the Engineer Department.*

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* Jedediah Smith, a trapper, explored the Colorado from the Virgin to the Mohave Valleys in September, 1826.

Captain Emory, Topographical Engineers, United States Army, in 1846–'47 crossed the river near the mouth of the Gila while *en route* to California as a member of the military command under Colonel Kearney, and there established a latitude station. (See Ex. Doc. No. 41, first session Thirtieth Congress.)

Parties of the Mexican Boundary Commission Survey reached the river at points near the Gila and to the southward in the years 1849, 1854, and 1855. The latitude and longitude of the junction of the Gila and Colorado was, for the first time, determined by Lieutenant Whipple, of the Topographical Engineers; and that part of the boundary from this locality to a point on the river 20 miles to the southward was determined, as also the latitude of the latter by the zenith telescope, by Lieutenant Michler, of the Corps of Topographical Engineers.

Lieutenant Parke, of the Corps of Topographical Engineers, while engaged on the Pacific Railroad surveys in 1855, crossed the Colorado at Fort Yuma, near the junction of the Gila, *en route* eastward to the Rio Grande.

The expedition of Lieutenant Ives, which took the field in 1857, the report of which appears in an executive document of the Thirty-sixth Congress, first sesssion, was the most important expedition ever fitted out for the direct and positive exploration and examination of the river from its mouth toward its source.

The work was in many respects most admirably done; and, although he failed to reach the highest point to which navigation could be directed in case of a commercial necessity, still, for the first time, he developed an understanding of the geographical position, topographical accessories, and the hydrographic peculiarities of nearly 600 miles of this hitherto almost unknown great river.

The next expedition was that sent out from Santa Fe in 1859, under Capt. J. N. Macomb, Corps of Topographical Engineers, with a view to determine the junction of the Grand and Green rivers. A point was reached by one of the parties of this expedition on the Grand River approximately 4 miles from and in view of the junction; from which locality the return trip was made to Santa Fe. The accounts of this expedition are to be found in the Annual Reports of the Chief of Topographical Engineers of 1860 and 1861, and in a special Geological Report by Professor Newberry published by the Engineer Department in 1876.

Meanwhile adventurous prospectors and others, doubtless, reached portions of the river below the mouth of the Grand Cañon. A monument on the northern shore found by a party of this survey in 1871 showed that the Grand Cañon had been entered from below by a party of four men, of whom O. D. Gass, met by myself in 1869 at Las Vegas, was one. This was probably in 1864.

Captain Rodgers, in October, 1866, took the steamer Esmeralda, 97 feet long and 22 feet wide, to Callville. (See Annual Report Chief of Engineers, 1868, Appendix X.)

One James White, with another prospector, attempted to descend the river in a raft from a point on the Grand in 1867, a brief narrative of which is related by C. C. Parry, assistant geologist Union Pacific Railroad Survey, in letter to J. D. Perry, Union Pacific Railroad, January 6, 1868, and submitted by Brevt. Lieut. Col. R. S. Williamson. (See Annual Report Chief of Engineers for 1868, p. 1191.) The following is compiled from the above report:

James White, formerly a resident of Kenosha, Wis., left Fort Dodge April 13, 1867, and, with a party under Captain Baker, made a prospecting tour of the San Juan region. Captain Baker was killed in a side cañon of the Green River, August 24, and White, accompanied by one Henry Strole, commenced the descent of the river on a rude raft, noticing the junction of the Green and Grand and the mouths of the San Juan and Little Colorado. Strole was washed overboard on the fourth day and was drowned. White then lashed himself to the raft and continued on the perilous journey, securing, by the barter of his arms to Indians, enough mesquit bread to sustain life till he reached Callville, on the Colorado, September 8, just fourteen days from the time of starting.

> "His narrative throughout bears all the evidences of entire reliability, and is sustained by collateral evidence, so that there is not the least room to doubt that he actually accomplished the journey and within the time mentioned by him."

The above narrative was corroborated by R. W. James, of the river party, who knew White well at Camp Mohave while the latter was a mail-rider between that point and Callville. So far as is known, he is the first white man who passed through the walls of any part of the Grand Cañon.

It is believed that Mr. John Moss and Capt. Samuel Adams subsequent to 1870 made trips in or about the cañon region, but no authentic account of critical observations by either of them is available.

The expedition down the river from the crossing of the Green River by the Union Pacific Railroad was undertaken by J. W. Powell in 1869, and carried out successfully. The several cañons through the Uintah Mountains, those between the junction of the Green and Grand, and the commencement of the Great Grand Cañon proper and the Grand Cañon itself, were passed by a boat party, which upon debarking reached the settlements from the mouth of Virgin River.

In 1870 the eastern boundary of Nevada was established by I. E. James, and the terminal point on the northern bank marked.

Subsequently, Mr. Powell, in his geological explorations and examinations of portions of the Colorado Plateau system, caused to be prosecuted geologic, topographic, and other examinations of sections bordering more especially upon the Grand Cañon both north and south of the river.

In the reconnaissance of 1869 I reached, with parties under my charge, the Colorado at the mouth of the Virgin River, and traveled along its northern and western banks as far to the south as El Dorado Cañon. In 1871 a regular boat party was organized by men selected from the expedition of that year, and the ascent of the river made from Camp Mohave through the Black, Boulder, Iceberg, Virgin Cañons, and the transit of a portion of the Grand Cañon, making a total distance of 205 miles, along which 225 rapids and falls were noted. In 1872 the river was traversed along its northern banks from the foot of the Grand Cañon to the mouth of Virgin River by myself and party. The river was approached by parties of the expedition of that year in the heart of the Grand Cañon at the mouth of the Paria and at the crossing of the "Fathers." (El Vado de los Padres.)

In 1873 the river was crossed at the mouth of the Paria by a party under Lieutenant Hoxie. In 1875 and 1876 Lieutenant Bergland, of the expeditions of those years, approached the river, making certain topographic and hydrographic examinations and surveys at points at and between Camp

Mohave and Fort Yuma. The source of the Grand River, one of the main tributaries, was discovered by Lieutenant Pike in his expedition of 1805 and 1806; that of the Green River (the main fork or continuation of the Colorado proper) by Captain Bonneville in his explorations of the years 1832 and 1833.

From such examinations as I have been able to make, the above appears to cover all the prominent explorations that have been conducted with a view to determine points upon the river itself, or the conditions of its hydrography or adjacent topography, and while it is not submitted as a complete account, still it is vouched for by such publications as it has been found possible to examine. Doubtless, a more thorough search among the writings of Herrera, Haykluyt, Torquemada, Ramusio, and others, of the travels of the Jesuits, and the manuscripts of Spanish travelers and explorers that may be found in the libraries at Madrid, Mexico, that of Bancroft in San Francisco, at the British Museum, and the Propaganda at Rome, and the Congressional Library at Washington, D. C., would bring to light new details, if not fresh facts.

The river has been crossed by railroad surveying parties, namely, those of the Texas Pacific, Southern Pacific, Thirty-fifth Parallel, and Atlantic Pacific, at points near the Mohave Valleys and Fort Yuma.

A brief abstract of the voyages and explorations above enumerated is herewith presented.

CHRONOLOGICAL ACCOUNT OF EXPLORATIONS OF THE COLORADO RIVER OF THE WEST.

PRIOR TO THE YEAR 1800.

Name of party.	Expeditionary year.	Authority for and remarks.
Capt. Francisco de Ulloa …	1539	Sailed up to the head of the Gulf, found the waters turbid from strong currents, and suspected but did not see the mouth of a great river. (See Annual Report United States Geographical Surveys, 1876.)
Captain Dias, of Coronado's expedition.	1540	Leaving the main command and proceeding westward discovered the Colorado and followed it to its mouth. (See Ives' Colorado River Report.)
Captain Cárdenas, of Coronado's expedition.	1540	Separating from the main command, reached the Moquis villages and probably some point in the cañon region to the north and westward. (See Ives' Colorado River Report.)
Capt. Fernando Alarcon ….	1540	Acting in conjunction with Coronado's expedition, ascended the Gulf of California and the river for a considerable distance for fifteen days in boats. (See Ives' Colorado River Report.)

CHRONOLOGICAL ACCOUNT OF EXPLORATIONS OF THE COLORADO RIVER OF THE WEST—Continued.

PRIOR TO THE YEAR 1800—Continued.

Name of party.	Expeditionary year.	Authority for and remarks.
Gov. Juan de Oñate	1604	Reached the river at junction of Santa Maria (Bill Williams' Fork) and followed it to its mouth. (H. L. Oak, of Bancroft's Library, San Francisco, Cal.)
Numbers of Catholic priests	from 1540 to 1740	Visited the lower part of the river in their missionary endeavors. (See Ives' Colorado River Report.)
Father Kino	1699 to 1702	A Jesuit priest who followed a land passage from New Mexico to California. (See Annual Report United States Geographical Surveys, 1878.)
Juan Ugarte	1721	Sailed along the east coast of Lower California, reaching the mouth of the Colorado in July, 1721.
Jacob Sedelmayer	1744	A Jesuit missionary who followed the Gila to the Colorado. Thirty years later missions were established near junctions of Gila and Colorado. (See Ives' Colorado River Report.)
Fernando Consak	1746	Similar trip to that of Ugarte, reaching the mouth of the Colorado on July 11, 1746, attempting to ascend the river with his canoes.
Juan Bautista Anza	1774	Crossed the Colorado overland from Sonora to Monterey, establishing a new route.
	1775	Crossed the Colorado *en route* from Sonora to Mission San Gabriel (a second journey to California).
Father Garces	1775	Traveled from Sonora through the Colorado River country; opens another route to the interior near southern end of the Sierra Nevada.
Father Escalante	1776	Crossed the Green and Grand rivers near their junction, and, returning from region of Great Salt Lake, forded the river at a point known as "El vado de los Padres," north of the Moquis towns. (See Warren's Memoir, Pacific Railroad Reports, Vol. XI.)
Father Font	1777	Crossed the Colorado at the Mohave Valleys *en route* from Monterey, Cal., to the Moquis villages. (See Warren's Memoir.)

SUBSEQUENT TO THE YEAR 1800.

Name of party.	Expeditionary year.	Authority for and remarks.
Jedediah Smith	1826	A trapper who explored the river from the Virgin to the Mohave Valleys in September, 1826. (Henry L. Oak, San Francisco, Cal.)
Bvt. Maj. W. H. Emory, Topographical Engineers.	1846-'47	Crossed the river below mouth of Gila *en route* to California. Observations and computations for time and latitude were made and published. (See Sen. Ex. Doc. No. 41, first session Thirtieth Congress, pp. 8, 255, and 256.)
Lieutenant Derby, Topographical Engineers, and Brevet Major Heintzelman, Second Infantry.	1850	Explored the river from its mouth to Fort Yuma. In Lieutenant Derby's case observations and computations were made for time and latitude and published. (See Sen. Ex. Doc. No 81, first session Thirty-second Congress.)
Captain Sitgreaves, Topographical Engineers.	1851	Traveled westward from Zuñi to the Colorado, and thence along the east bank to Fort Yuma. Observations and computations were made by Captain Sitgreaves and Lieutenant Parke for time and longitude and published. (See Senate Ex. Doc. No. 59, second session, Thirty-second Congress, pp. 5 and 24.)
United States and Mexican Boundary Commission.	1849, 1854, 1855	Lieutenant Whipple, Topographical Engineers, under Brevet Major Emory, Topographical Engineers, established and published latitude and longitude of junction of Gila and Colorado. Lieutenant Michler, Topographical Engineers, in winter of 1854-'55, ran that part of boundary from the Gila to a point 20 miles below. Observations and computations for time and latitude were made and published. (See Report of Mexican Boundary Commission, Vol. I.)

CHRONOLOGICAL ACCOUNT OF EXPLORATIONS OF THE COLORADO RIVER OF THE WEST—Continued.

SUBSEQUENT TO THE YEAR [illegible]—Continued.

Name of party.	Expeditionary year.	Authority for and remarks.
Captain Whipple, Topographical Engineers.	1854	Pacific Railroad Surveys. Traversed the east bank from Bill Williams' Fork to the Mohave Valley, whence he crossed to the westward. Observations and computations for time and latitude were made and published. (See Vol. IV, Pacific Railroad Reports.)
Lieutenant Parke, Topographical Engineers.	1855	On Pacific Railroad survey duty, crossed the Colorado at Fort Yuma. (See Vol. VII, Pacific Railroad Reports, Appendix D.)
Lieutenant Ives, Topographical Engineers.	November 28, 1857, to March 23, 1858.	Ascended the river from its mouth to the head of Black Cañon. Observations and computations for time, latitude, and longitude were made and published. (See Ives' Report.) Lieutenant Ives, during land trip from Camp Mohave to Fort Defiance, reached the mouth of Diamond Creek and a point (Aubrey Cliffs) on the southern edge of the Grand Cañon.
Captain Macomb, Topographical Engineers.	1859	The party reached a point on the Grand River approximately 4 miles above its junction with the Green. (See Annual Reports Chief of Topographical Engineers, 1860, p. 252, and 1861, p. 425; also Senate Ex. Doc. No. 1, Thirty-sixth Congress, second session, and Report of Macomb Expedition, with geological report of Professor Newberry, published by the Engineer Department, 1876.)
J. W. Powell	1869	Descended from crossing of Green River by Union Pacific Railroad to mouth of the Virgin, traversing the Grand Cañon. Subsequently, during a number of years, parties under his direction visited the plateau region of the Grand and adjacent cañons both north and south of the river. (See reports upon "Exploration of the Colorado River of the West," 1875, and of the Geological Survey of the Rocky Mountain Region.)
Lieutenant Wheeler, Corps of Engineers.	1869	Examined the river on the northern side from mouth of the Virgin to El Dorado Cañon. Observations and computations by Lieutenants Wheeler and Lockwood for time and latitude were made and published. (See Progress Report of United States Geographical Surveys for 1869, p. 72; also Annual Report for 1876, p. 12.)
Do	1871	Ascended the river in boats from Camp Mohave to the mouth of Diamond Creek, in the heart of the Grand Cañon. (See Progress Report Geographical Surveys West of the 100th Meridian for 1871.) Observations and computations for time and latitude were made and published. (See Annual Report of Geographical Surveys West of the 100th Meridian for 1872.)
Do	1873	He traversed the northern banks of the river from the foot of the Grand Cañon to the mouth of the Virgin River in 1872. Lieutenant Marshall made observations for time and latitude on river above Grand Cañon in 1872, that were published. A party of his command crossed the river at the mouth of the Paria in 1873, and during the years 1871, 1872, 1873, 1875, and 1876 parties of this expedition by land approaches surveyed, mapped, and otherwise examined large areas bordering upon the Grand Cañon region both north and south of the river, and also at points on the river between Camp Mohave and Fort Yuma. Lieutenant Bergland during winter of 1875 and 1876 made observations and computations for time and latitude on this portion of the river. (See Reports of United States Geographical Surveys West of the 100th Meridian.)

ASCENT OF THE COLORADO RIVER AND EXPLORATION OF THE GRAND CAÑON TO THE MOUTH OF DIAMOND CREEK IN 1871.

The report of the results from this special party of the expedition of 1871 is made in itinerary form, as the examinations presented special features, making this boat trip an expedition in itself and the route prominent above all others.

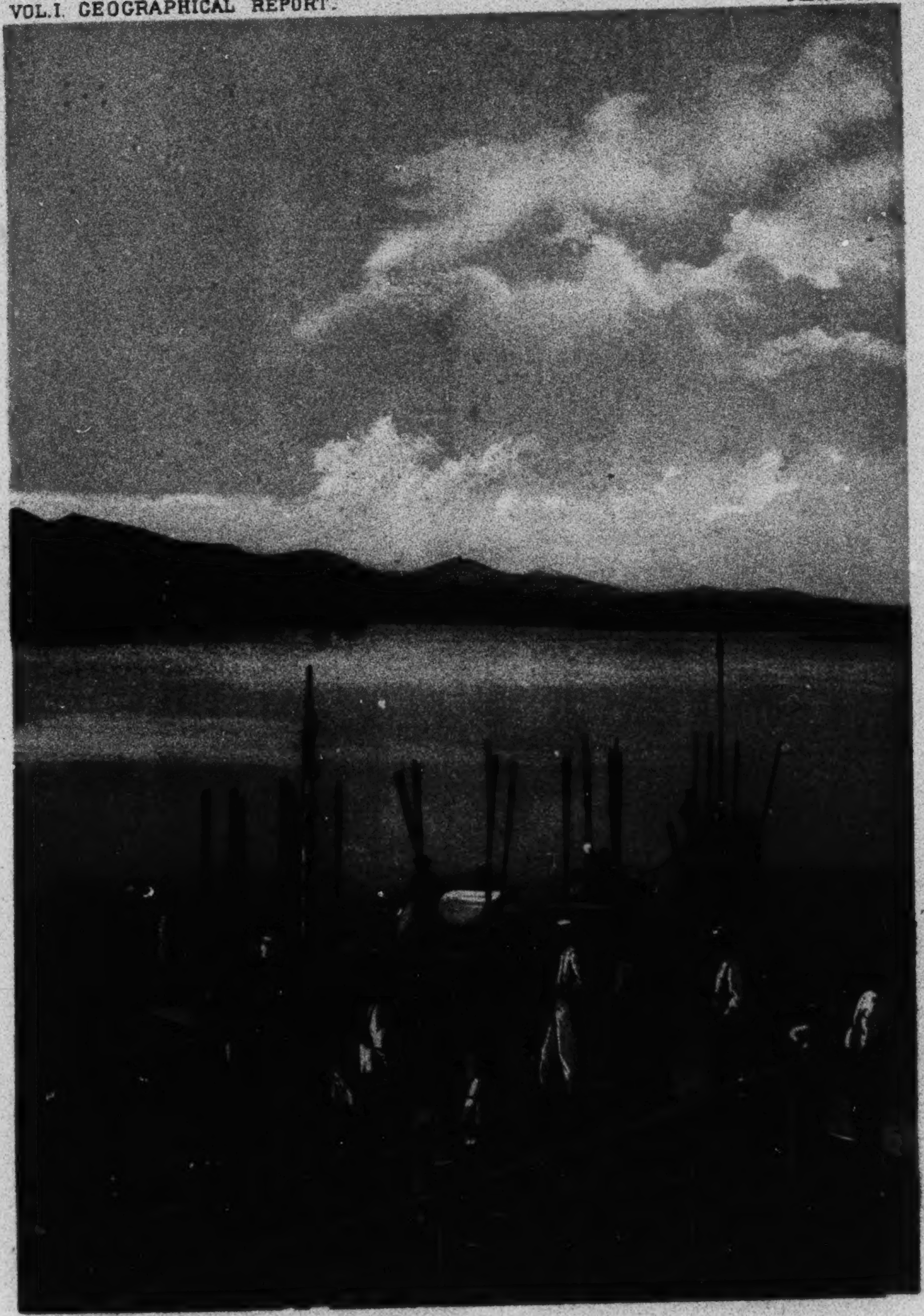
The river party left camp at Cottonwood Springs, on the east base of the Spring Mountain Range, Nevada, and, traveling by the most direct line of march, reached Camp Mohave on the evening of the 12th of September. Here were stored the boats, three in number, that had been constructed in San Francisco and shipped via the mouth of the Colorado to this point. In addition thereto, one barge, the property of the Quartermaster's Department, through the courtesy of the commanding officer, Bvt. Maj. R. H. Pond, at Camp Mohave, was added to the little fleet.

Time had been most actively employed in concluding the arrangements necessary for the trip, among which was the making of terms with the Mohaves, whose services were actually necessary in order to carry out the enterprise. Captain Asquit, the second peace captain of the tribe, and thirteen others, finally decided to attempt the trip, although they were timid and greatly feared the dangers of the region outside of the country of the Mohaves.

Plate No. XVI, herewith, is a sketch from a photograph of the little fleet as it left the ferry dock at Camp Mohave, with officers, soldiers, citizens, and Indians, on the ferry-boat, wharf, and river bank to bid adieu and god-speed in the long and perilous trip to the then little known region of the Grand Cañon.

The river party consisted, in addition to myself, of P. W. Hamel, topographer; G. K. Gilbert, geologist; Dr. W. J. Hoffman, naturalist; T. H. O'Sullivan, photographer; E. M. Richardson, assistant topographer and artist; Frank Hecox, barometric assistant; F. W. Loring, general assistant; six boatmen, six enlisted men (one sergeant and five privates from Company G, Twelfth Infantry) from Camp Mohave, and Captain Asquit and thirteen other Indians of the Mohave tribe.

I wish here to renew my appreciation of the kindness extended by all the officers then stationed at Camp Mohave, especially to Bvt. Maj. R. H.



THE START OF THE RIVER PARTY FROM CAMP MOHAVE, ARIZONA.

(EXPLORATIONS OF 1871.)

Pond, commanding, and Lieut. Charles P. Eagan, quartermaster and commissary.

September 16.—River Camp No. 1, near the old mill at Hardyville.* About 1 p. m., by hard rowing, the boats and barge were fairly under headway in the stream, but on account of the current were soon obliged to put out the tow-lines. These are firmly handled by the different members of the party, all of whom are possessed of a genuine enthusiasm for the trip, and the boats, except No. 2, anchored at the mill near Hardyville, reaching the camp about dusk. The Indians so far feel well disposed, having the promise of a good time and plenty to eat.

September 17.—River Camp No. 2, near foot of Mount Newberry. Estimated distance traveled about 15 miles, towing greater part of the day. Alexander's Camp was passed about 1¼ miles above Hardyville. This is the highest point at which the Colorado River was then crossed by a ferry. One has since been established at the mouth of the Virgin River, whence a road to the southward reaches the Hualapais mines. Pyramid Cañon was passed (see Ives's Report) and camp made on the eastern side of the river, nearly opposite Mount Newberry. A treaty relative to rations (the first discipline applied to the Indians in regard to subsistence) was here made. As the land of the Pah-utes, with whom the Mohaves were lately at war, will soon be reached, strong guards are therefore necessary. The parties all sleep in a line along the low sandy beach. Travelled a distance of approximately 15 miles. The float rock in the washes indicate that the Black Mountains to the east are volcanic.

September 18.—River Camp No. 3, foot of Painted Cañon. This morning the first considerable rapids are met just above the camp, and the entire party are obliged to take hold of the line. Above this point to Cottonwood Island the river flows with a lesser current, and a favorable wind allows of the use of sails. The island is reached shortly after meridian, where ruins of two huts formerly occupied by white men are alone seen. Near here crosses the mail trail from Camp Mohave to Saint Thomas and other towns in Southern Utah.

The Pah-utes have left this locality since their late trouble with the Mohaves, and it is now neutral ground. The island is nearly 7 miles long, is quite narrow, but covered by a fine coat of rich alluvium. From this point, the sails being again set, we reach a delightful little camp at Painted Cañon, named after the variegated lavas of its walls, where the boats are beached and overhauled. Observations for latitude were here taken, and also a section of the river.

September 19.—River Camp No. 4, near Big Bend. At the last camp the camera was first called into requisition. In the early part of the day the boats thread their way easily through Painted Cañon, passing the small round island shown on Ives's map, near which cemented gravel mesas in bold bluffs of 150 feet are noted. Camp is made along a narrow sand strip just above the first noticeable bend of the river. Nothing of marked interest is noted except the peculiar mountain forms, many dark and others variegated, that project from the sandy mesas along the banks, and the variety of miniature cañons entering into the main or Painted Cañon from both sides. Observations for latitude are taken.

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* See map for location of the several camps.

September 20.—River Camp No. 5, mouth of El Dorado Cañon. The day has been warm, progress slow and tedious. Several rapids stronger than those heretofore have been encountered, and they are becoming gradually more difficult to pass on account of the steepness of the banks. A number of curiously eroded beds of half consolidated gravel are seen, especially on the eastern bank. The growing moon lends its attraction to the camp, situated near the old quartz mill, the point reached by Lieutenant Lockwood and myself in 1869, in crossing the desert from Las Vegas ranch, via Forlorn Hope Springs. A lava butte of brown and orange colors on the Arizona side is passed. The river is the color of red clay and quite as thick as the Missouri. The Black Cañon in advance seems to be an eroded channel through dark volcanic rock, while near its foot volcanic conglomerate appears. Sextant observations taken for time and latitude.

September 21.—River Camp No. 6, Black Cañon, below Roaring Rapids. A redistribution of boat parties is made and a rendezvous fixed for a camp above the Black Cañon. One boat following in the rear, which contains the photographer and his outfit, is called the "Picture." There are still short spaces along which rowing may be done. Several rapids are passed during the day, but none that give the barge much difficulty except at the mouth of a cañon coming in from the west. Observations made for time and latitude.

September 22.—Camp No. 7, above Roaring Rapids. A reconnaissance, following the Wash and reaching the heart of the ridge on the west side of the Black Cañon, proves the existence of a pass leading toward Las Vegas Springs and ranch, and of water in little pools here and there, and of natural tanks cut in pot-hole shapes in the walls of the winding cañon. Pass Roaring Rapids (see Ives's Report) during the day; also a cave on the western bank, known as Conner's Cave.

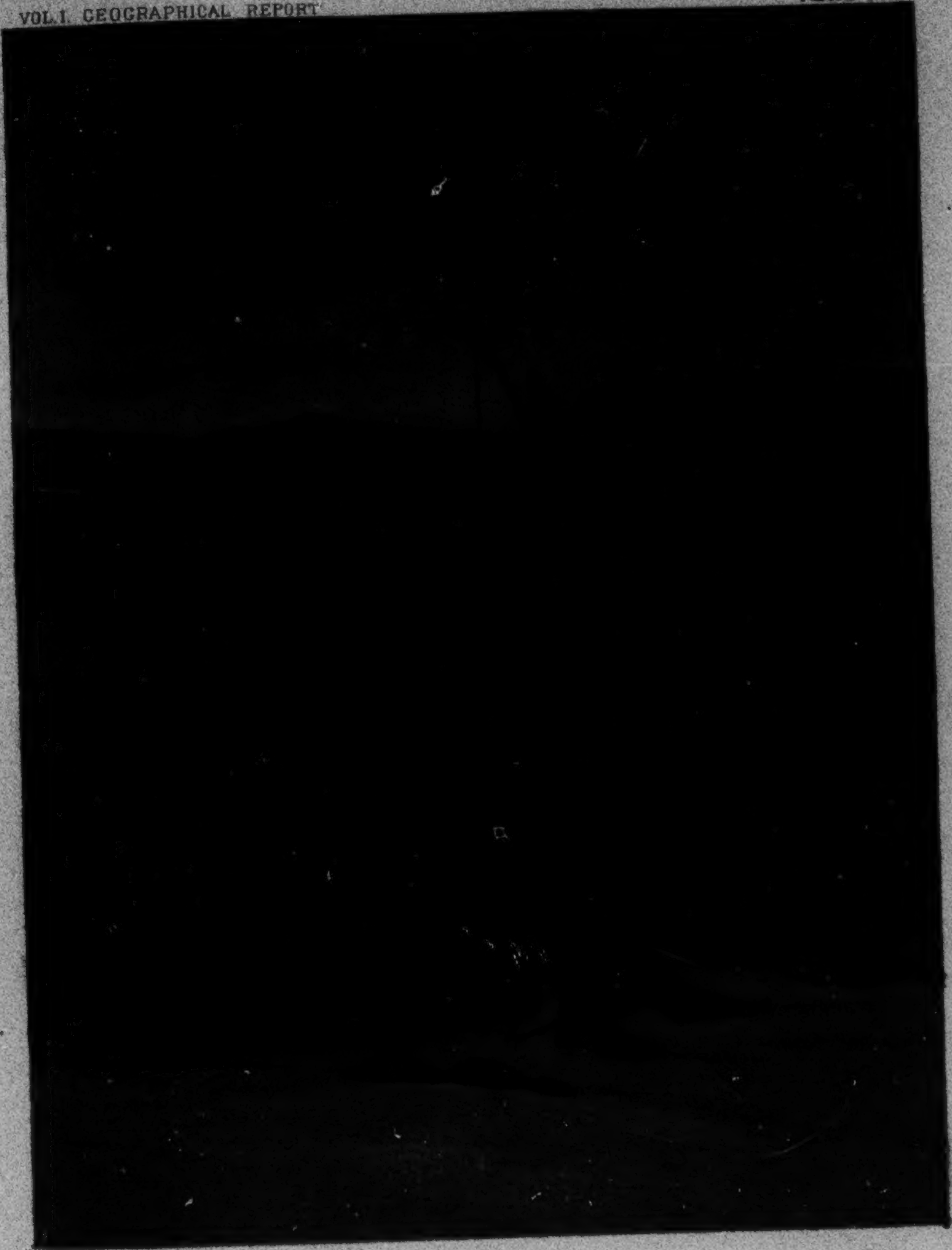
September 23.—Reached Camp No. 8, heart of Black Cañon, above "Violent Rapids" of Ives. The walls of the cañon at this point make apparent sunrise very late, and not until 6.30 a. m. does this messenger appear. The sunshine does not reach the river part of the cañon for one-third of the daytime, as the walls, varying from five to fifteen and even seventeen hundred feet in height, approach perpendicularity in this portion of the cañon. To the east plateau beds rise from three to four thousand feet above the river. To the west the Black Cañon range, so called, is composed of volcanic material overlying sedimentary rocks.

The moon is now so far increased that the last two evenings in the Black Cañon have been most picturesque and lovely. The rapids on to-day's route have been severe, delaying the barge and obliging a portage of much of its cargo. We were unfortunate in capturing game, whether mammals or birds, although the tracks of deer and mountain sheep, probably coming to the river for water, are noted at the entrance of nearly every side cañon; still little game is secured, while now and then flocks of duck, sandhill cranes, and pelicans are seen, but rise, as a rule, beyond gunshot range.

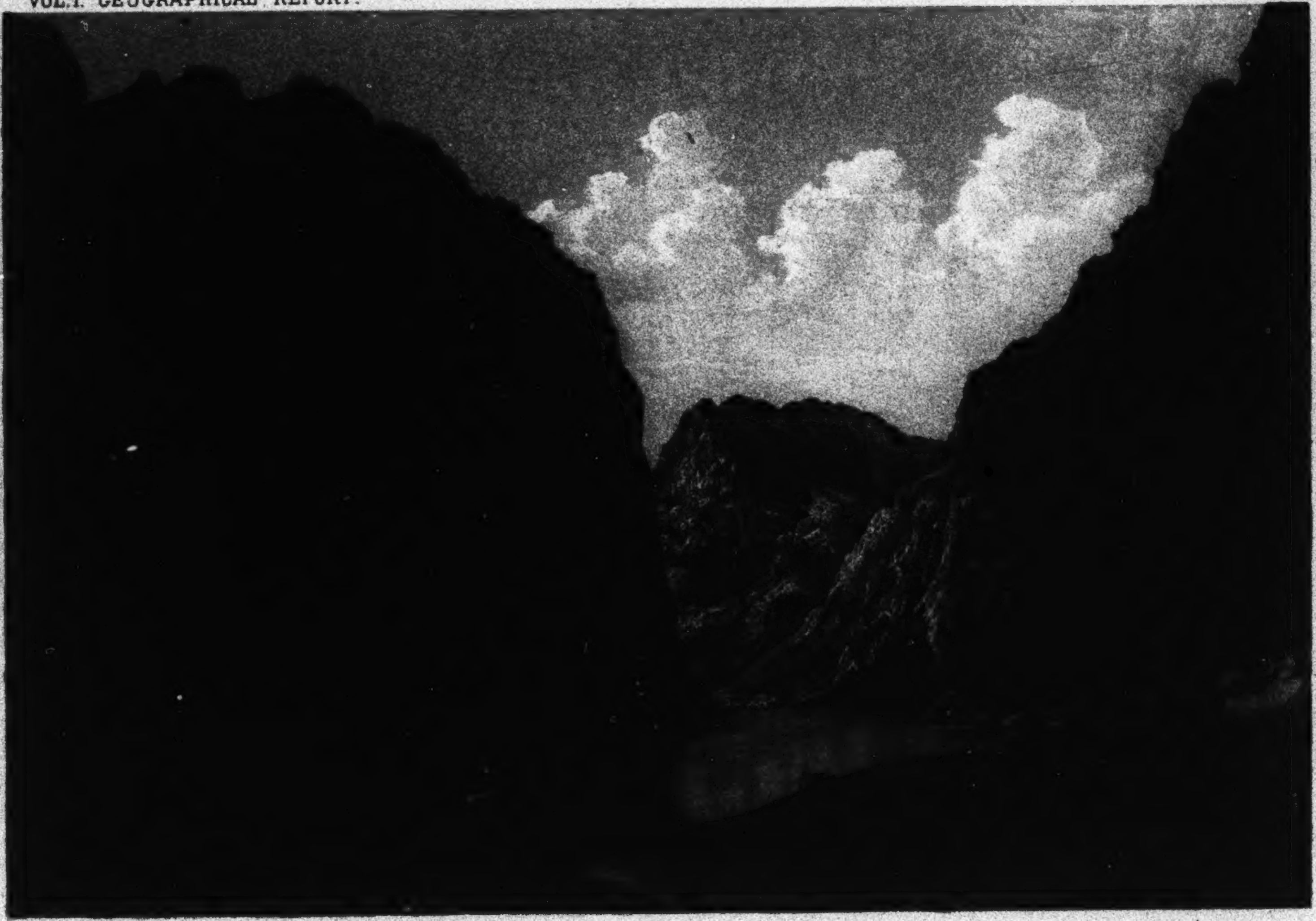
Plate No. XVII.—This is from a photograph by O'Sullivan, taken near the center of Black Cañon. The name "Gibraltar" has been proposed for the somewhat pointed bluff noticeable on the west shore.

Plate No. XVIII.—A sketch showing Maimum, a young and typical Mohave, in the foreground, is here introduced, as he was one of the characters of the trip. His lithe and supple form made him

BLACK CAÑON, COLORADO RIVER, FROM CAMP 8, LOOKING ABOVE.
1871.



MAIMUN-A MOHAVE INDIAN OF THE RIVER PARTY.
1871



BLACK CANON OF THE COLORADO RIVER, FROM MIRROR BAR.

1871.

an object of pleasure to observe, while his childish enthusiasm and frankness were often turned to good account when the war councils of the fourteen Mohaves threatened disturbance. He became much attached to young Loring, who, with Messrs. Hamel and Salmon, of the river party, were the victims of the Wickenburg stage massacre, and, singularly enough, in company with other Mohaves, became one of the detectives to discover the Apache Mohaves who perpetrated this most terrible outrage.

September 24.—Reached Camp No. 9, head of Black Cañon.—The necessity for reaching the land parties at the crossing near the foot of the Grand Cañon does not permit of our resting even on Sunday. By diligent labor camp at the head of the cañon is reached, where the walls are quite abrupt and fully 1,700 feet in height. This brings us out to daylight once more. During the day several rapids have been passed, none very difficult except one, which will be called Horseshoe Rapids, because of its form.

Here the face of the current strikes the western bank and from it rebounds to the south and east with impinging force along a collection of seemingly small boulders; and upon striking the sharp bluff along the eastern shore takes a similar turn to the southwest. This rapid delayed us two hours. The channel has been deep and the water smooth, although the current was strong. The walls of the cañon have exceeded the usual height, and come for the greater part to the immediate edge of the water, bordered, however, at intervals by little sand banks. The walls of the cañon near its head are composed of a highly metamorphic sandstone, exposing here and there brecciated cliffs and conglomerate boulders.

The Black Cañon, although interesting in the extreme, does not equal in grandeur what was expected of it from the description given in Ives's Report. The walls are not so high nor as vertical as therein represented. However, the velocity of the current and number of rapids that are met, the sombre character of the walls, many peculiar weird forms, points at which a stillness like death creates impressions of awe, all tend to the belief that one of nature's grand labyrinths has been passed.

Plate No. XIX has been selected from the photographic subjects as typical of Black Cañon between Camp 8 and its head. The walls in other places are more abrupt and their perpendicularity at the water's surface more marked, thereby presenting scene after scene of rare grandeur, but wanting in the gentler undulations of form shown in the sketch from "Mirror Bar."

September 25.—Reaching River Camp No. 10, in sight of Callville (deserted). An early start soon brings us past Fortification Rock to the mouth of Las Vegas Wash. A considerable rapid is passed near the head of the cañon. Those encountered later in the day were less violent, as the river spreads over a wider space. There is a marked change in the temperature. The equinoctial having passed, there are fewer changes in the increased currents due to local precipitation at points nearer the sources.

Las Vegas Wash was passed at noon, and thus have had views on three sides of the isolated peak which will be called Black Butte. Fortification Mountain is in sight during the entire day. The shallow rapid opposite Las Vegas Wash contained sufficient water to allow the passage of the barge, which only reached camp at 11 p. m. The brightness of the moon affords, however, a light nearly equal to that of day. Table Mountain, nearly opposite the head of Black Cañon, an elevation of approximately 2,250 feet, is one of the marked features. The immediate cañon walls are not greatly in excess of 1,000 feet, while protruding points are from 1,750 to 2,000 feet, approximately.

September 26.—Reaching River Camp No. 11, near the foot of Boulder Cañon. This point, a short distance within Boulder Cañon, has been selected as a rendezvous. Leaving the boats for a while, following up the wash that comes in from the south at a point in sight of Callville, an Indian trail, supposed to lead into the Hualapais country, is noted. One of the boatmen says that the Hualapais and Pah-utes cross the river at this point and interchange commodities. It is called one and a half days' long Indian marches, probably 75 miles, to the Hualapais mining district.

The walls of Fortification Rock seem to be sandstone highly metamorphosed, while those in Boulder Cañon are of granite. Floating pieces of iron ore (hematite) are noticed in the wash. Here in a marked degree is shown the large annual denudation of these sandy and conglomerate mesa forms. Thus is it made clearly manifest that the erosive agents of nature little by little are decreasing the profile of all mountain forms.

The Indians exchange powder and ball for sheep and buckskin, the Pah-utes buying from the emigrants.

September 27.—At Lay-Over Camp. Astronomic and magnetic observations are here made, the former having been taken at all other camps. The boats and barge are carefully overhauled, cleaned, and caulked. Reports were heard of gold ore having been found near the wash that leads into the river from the south, at the mouth of which camp is made. This day of rest, being the first since the commencement of the trip, is heartily appreciated. The "Picture" comes up a little before noon, and the party are all together again. The photographic party have met with good success. Having rationed anew, they will still continue on a roving commission until the rendezvous at the crossing is made.

September 28.—Reached River Camp No. 12, near head of Boulder Cañon. Being anxious to arrive at the crossing, an early start is made, and all the force crowded to its utmost. A severe wind storm is met near the head of the cañon, and the party becomes divided, one portion camping at the head of the cañon and another fully 2 miles above. At the former camp a gale fills the air with sand so completely that it could not be kept out of the food, and during the night formed in drifts, covering the blanket beds.

Mr. Gilbert furnishes the following general section of Boulder Cañon: a nucleus of syenite, against which rest plicated crystalline schists, and over the whole are successive massive layers of trachyte, flanked at the east by basalt.

September 29.—Camp No. 13, near mouth of Virgin River. The river here makes a sudden bend to the southward, and although the right-line distance to the mouth of the Virgin River does not exceed 5 miles, by the river course it is fully 10. The rapids encountered to-day are less violent than usual. Two settlers are found, who have just arrived for the purpose of establishing a ferry to aid prospectors *en route* to the Hualapais mines, in Arizona. They have found a good road to the head of the Sacramento Valley, which to the southward skirts the mountains to the eastward of this valley. An Indian was here found with a note from the guide, Spencer, which gives hope that he will accomplish his difficult mission of selecting a camp on the south of the river for a land rendezvous after having planted signals at the mouth of Diamond Creek, the objective point of the river party, and having selected a crossing and made a junction with the land command near Saint George, Utah.

The territory of the Pah-utes, who have lately been at war with the Mohaves, has been successfully traversed and neutral ground reached. The Mohaves held a long conference with the Pah-utes of the Muddy region, several of whom live in this locality.

A singular salt well on the mesa was visited. The elevation is found to be approximately 50 feet above the river. It is doubtless a reservoir of waters accumulating on the rock bed that here ascends nearer to the mesa surface.

September 30.—River Camp No. 14, near Notre Dame Rock. A distance of from 13 to 14 miles was traveled and camp made on the southern bank a little after dark. A heavy rapid was passed a little less than 1 mile below camp, and also during the day, on the southern side, peculiar mesa forms, denoted respectively as Dome Rock and the Cloister. The river here bends considerably to the south. The barge moves slowly, and the duty forced upon the white men, who have to go frequently into the water, is very severe. One sees what appears to be a high range of mountains about 30 miles distant, apparently perpendicular, which is presumed to be the commencement of the Grand Cañon.

October 1.—Reach Camp No. 15, above Long Rapid. Rattlesnakes have been very plenty along the sides of the cañon. To-day Notre Dame and Cathedral Rocks were passed, and a little higher another mesa, islands that are the commencement of the cañon cut out by the river from the Virgin Range. As this is our first cañon upon entirely new ground it will be called Virgin Cañon. Two or three slight rapids are passed, and a very large one at the head of the cañon, by far the most violent yet seen. The difficulties of towing have been very great. A salt spring is noted on the southern bank, near the center of the cañon.

October 2.—Reached Camp No. 16, foot of Iceberg Cañon. Emerging from the cañon are some lone rocks, against which the water breaks heavily in the flood season. An island appears here which is doubtless covered at high water. Indians approached from the southern bank and proved to be Pah-utes, who are planting a small strip of land near the river. They bring squashes, melons, and nets, to trade. They seem to be entirely sequestered from the other Pah-utes, and have no news except that they have apparently seen the source of Truxton Springs. It is surmised that they have seen white men cross the river a little above the Grand Wash. The Mohaves are getting tired and lazy, and the boats move wearily, passing a wash coming in from the north, and next a rapid, just at the foot of the cañon, that, because of the peculiar contour of its northern walls, is called Iceberg Cañon. The barge, as usual, does not reach camp until after dusk.

October 3.—Camp No. 17, foot of Grand Wash, Iceberg Cañon. The peculiar shades of color drifting in the strata, and the contour of the prominent walls have all been most singular in this cañon. The progress to day is slow, and at night the distance traveled is not more than 7 or 8 miles.

October 4.—Camp No. 18, crossing of the Colorado. To-day beaver-holes were noted and paths very plentiful along the river. One boat pushes ahead to reach the point of crossing, where it is expected to meet one of the land parties prior to October 5. The barge and other boats are left, with orders to come in as rapidly as possible. The walls of the cañon are soon passed, and what seems to be the extreme face of what well could be the beginning of the Grand Cañon is seen. In between are numbers of broken washes of semi-plateau slopes. In less than a mile horse-tracks are discovered, and it is concluded that a few horsemen had camped there some days since. In tracing these up the river the land camp would doubtless be struck. Traveling ahead alone on foot on the river bank voices are soon heard, and it is found that Lieutenant Lockwood and his party had come to the river, thinking it might be necessary to build a raft, and had gone a little way up the river to the old Ute crossing to get timbers and find a trail on the other side. Our meeting here was a cause for mutual congratulation. Here the mail is received, and parties at once dispatched to bring the main command to the crossing. Our rendezvous camp is made on the southern side, and every one is gladdened to know that the most difficult enterprise of the expedition has been so far consummated in a most satisfactory manner.

October 5.—At the crossing of the Colorado. The day was spent in camp in pleasant intercourse, making arrangements for further operations, and the opportunity is taken advantage of to thoroughly overhaul the barge and boats. The former is to be left at the old Ute crossing, about 3 miles above the camp. The start will be made with picked crews, rationed for 15 days, hoping to reach the mouth of Diamond Creek in that time. The barge will form the basis of supply in case the difficulties of the ascent necessitate falling back upon it. Good grass is found upon the plateau about a mile and a half to the southward, where the animals can recuperate. A marked change as to the conditions of grazing is noticed at once upon crossing the river. Between the walls of the cañon to the east and the Virgin range to the west, nearly as far north as Saint George, Utah, is an area almost entirely destitute of grass, while every plateau, with its contiguous mesas, is covered with a thick bed, as one passes to the southward.

Parties of relief are projected, to reach the crossing from the rendezvous at Truxton Springs with further rations in case of disaster. Another party is to attain the mouth of Diamond Creek, which is about 35 miles from the general rendezvous. Different routes of travel to be followed between now and the close of the season are discussed and arranged. About 4 o'clock the command begins to file down to the river bank and is brought across the river as fast as the different parties come up. All the boats are brought into requisition and the concentrated force quickly completes the crossing. The entire expedition is safe on the southern side of this turbid, unmanageable stream; and thus the greatest and most extraordinary obstacles of the season are successfully passed.

Friday, October 6.—At crossing of the Colorado. All the animals are brought across this morning by swimming against a fierce current with a single loss. Mr. Gilbert proceeds with his boat to the mouth of the Grand Cañon with a view of making a geological section at this point. He succeeds in reaching the high mesa, about 3,500 feet, but is unable to return to the bed of the river before dark, and makes his camp high up in the rocks.

The Mohaves have a great feast over the animal that was killed in crossing, and in consequence many are sick; but the presence of a Pah-ute medicine-man has its influence in relieving the horrible pains of several of the overfed aboriginals. A greater part of the day has been made hideous by his roars, screams, and moans over

MOUTH OF THE LOWER GRAND CAÑON OF THE COLORADO RIVER.
1871

the victims. For the third time the Mohaves have tried to desert and return to their homes. By dint of threats and persuasions they are, however, induced to remain until the completion of the river exploration. Observations are here made by Lieutenant Lockwood and myself for time and latitude. The barge is left near the crossing as the nucleus of a relief station, and with it Sergeant Eisenbise, one soldier, Captain Asquit, and three other Indians. The cañon exploration is to be made by 3 crews of 9 persons each.

October 7.—Camp No. 19, near foot of the Grand Cañon. The land parties are left this morning to take one more day for recuperation, and the three boat parties merrily start out to search for further wonders in the Grand Cañon, imagining but few of the many difficulties that were soon to be met.

Gilbert Camp is reached at 1 p. m., but he had not then returned from the summit of the plateau. A little farther on a full view, magnificent beyond description, of the walls of the Grand Cañon is had. Camp is made after nightfall on the southern shore, near a little stream trickling from the sides of the cañon. Sheltered by the foliage that clusters around this little ravine one manages to protect himself from the wind-drifting sand. In the vicinity of the old Ute crossing, near the foot of the Grand Cañon, the river widens and the rapids are more shallow. This is the best point yet noted for fording, still in the lowest of waters swimming would be necessary, and at high water doubtless the swift current would prohibit this method even.

Plate No. XX is an illuminated sketch made from a photograph taken in the Grand Cañon near its mouth, and is hence typical as to form, showing peculiarities of erosion that give rise to great varieties of profiles. The coloring is in some respects more brilliant than that in nature, although less vivid than in some of the beds, as, for instance, the red wall of limestone. The sun breaking through upon the vari-colored sedimentary beds enlivens a contrast of colors that no artist can accurately copy.

October 8.—Camp No. 20, head of Winding Rapids. In following up the little ravine near the camp the source of its pure stream of water is discovered, and near it most beautiful beds of ferns. The photographer remains in this locality taking views. The springs near the Tufa Bluffs, on the north side, not far from our former camp, were examined and four were named—Tufa, Grotto, Baptismal Font, and Holy Water Cup. The temperature of these springs is 70 degrees Fahrenheit. The water is most clear and sparkling. A small stream of water, entering the river from a side cañon to the south, was passed where elm trees were seen. Five rapids are passed within two miles. A section of the river is here made by Mr. Hamel, and observations for time and latitude are taken by myself.

October 9.—River Camp No. 21, near Cascade Rapids. Camp is broken early and the start made in fine style. It is hoped this day to make considerable distance, but soon many rapids are stumbled across, and at noon 9 had been passed, and prior to sunset, 15, some of which had as many as three falls. Observed three tufa mineral springs about noon, temperature 70 degrees. During the day a monument on the north shore was passed, in which was found a memorandum signed by "4" men, one of whom was O. D. Gass, of Las Vegas Ranch, Nevada, who had ascended to this point in 1864 (?) (The "4" was partly obliterated.)

The rapids are more formidable than any yet seen. I am satisfied that no one has ever ascended the river above this point, and Mr. Gass, one of the 4 persons mentioned above, told me in 1869 at Las Vegas ranch that he considered it impossible to penetrate farther. It is for this party to try it, however, and if successful to-morrow there will seem to be little doubt of reaching Diamond Creek. Traveled 7½ miles to-day. The narrowest point in the river yet reached is immediately above Tufa Springs—75 feet. Its bed here is one of erosion through the underlying granite walls rising on either side. The coarse carving, noted in detail on the limestone and bowlders of *débris* beaches, is here shown on a grander and more picturesque scale than elsewhere seen. The geological horizon of granite is just reached, and it is not improbable that it extends as far as Diamond Creek, where it was noted by Dr. Newberry, in 1858. A wash with high banks comes in at the camp from the north and is covered with driftwood, evidencing the rise at stages of high water.

Plate XXI here introduced shows a projecting rock on the right hand of the sketch called "Devil's Anvil," that overhangs the almost perpendicular cañon. Part of the southern wall is shown, and also the river-bed. The photographic view was taken at a point a little higher up than Diamond Creek by one of the land parties of 1872.

October 10.—River Camp No. 22, opposite Vernal Falls. We traveled this day not far from five miles. Two boats are lost over the rapid immediately in front of our camp, but secured again without damage. Early to-day a rapid is passed with a direct fall of at least 8 feet. The entire fall of the rapid before mentioned is 35 feet, above which comes smooth water for approximately 1½ miles, flowing along solid granite walls of the cañons on either side. Another rapid met during the day calls for all the strength of the different crews. Much water has been taken by the boats. At last a long rapid of two falls appears, with smooth water at its head, extending for quite a distance. The boats succeed in passing the first one a little after dark. It is not considered safe to try the other, as everything has to be unloaded and the first boat has been very nearly swamped. Therefore a dark and dreary camp is made among the *débris* of the slopes, where, cuddled up Indian fashion, the weary hours of the night are passed. The labor of the past few days has been very wearing upon the men, and one of the strongest Indians was thrown upon the rocks and badly bruised, making two invalids in the party. I have several times during the day despaired of reaching Diamond Creek in time to join the relief party there, as each rapid in turn seems to be more powerful than the last, and the number per mile is evidently on the increase; and, furthermore, it appears unlikely that any party has ascended the river farther than this locality, or that one ever will. Still, the objective point can be reached, it is believed, if the men and boats hold together. Traveled approximately 5 miles and camped on north shore.

October 11.—Camp No. 23, below Disaster Rapid. This morning Mr. Gilbert makes certain special geological examinations, among others examining an injected dikelike mass of basalt in the granite. Portage is made, and the rapid near camp passed. Another appears within one fourth of a mile, then smooth water for a little distance, after which a powerful rapid that takes the strength of all of the three crews. Then appears another stretch of fair water that brings one to the worst rapid of the trip. All the boats are brought up and lines thrown ahead. This rapid seemed long but not dangerous, however, but the first boat going into it proved differently. The first dash filled the boat with water, the second swamped it, and in this way the lives of two boatmen were endangered. The boat ran back against the rocks almost a perfect wreck, and its contents were washed down below the overhanging rocks. A stout case containing my most valuable private and public papers and data for a great

VIEW LOOKING SOUTH INTO THE GRAND CAÑON OF THE COLORADO,

FROM SHEAVWITZ CROSSING.

1872.

share of the season's report, which for the first time had not been taken out of the boat at a portage, was lost, as well as valuable instruments, the astronomical and meteorological observations, and worse than all the entire rations of that boat. These losses could not be made good, and this disaster threatened to drive the cañon parties back to the bargé station at the crossing, thus pronouncing the trip a partial failure. Night came, and the boats dropped back about half a mile to camp. Weary myself and much dispirited, it is still necessary to maintain cheerfulness toward the little party, who see great trouble ahead. A compact vein of basaltic lava of 6 feet thickness obtruding through the granite was noticed, as also like intrusions at a number of points elsewhere on either side of the cañon. The granite [illegible]ws higher and is beautifully sculptured in pot-holes and other forms.

October 12.—Reached Camp No. 24, head of Disaster Rapid. The morning is occupied in searching up and down the river for any trace of articles lost from boat No. 1, but without success. Our party are all despondent, and as the boat swamped yesterday was badly damaged, and rations are very short, a portion of the party is here detached to make the descent in this boat, with the expectation of reaching the land party and following their trail to the southward from the point on the river where the barge lies anchored. No one except Mr. Gilbert and myself think that the boats can pass the rapids in front of us. It requires no little courage to continue farther on, since one day later would prevent a return in time to meet the relief party at the river-crossing, and the barge has rations only up to a certain date. Mr. Gilbert and myself propose to reassure the men by taking the first boat across the rapid. Portage of the stores is made to the wash at the head of the rapids, which consumes the greater share of the day, and half an hour before twilight a rope is stretched and the emergency prepared for. The entire force is stationed along the line, and the cast-off is made. In five minutes the worst part of the rapid is over, and just as the sun sinks gloomily behind the cañon horizon the worst rapid is triumphantly passed, amid the cheers and exultations of every member of the party. Astronomical observations were made here.

October 13.—River Camp No. 25. This morning the second boat passes Disaster Rapid successfully, and a fresh start for the farther ascent is made. Three other severe rapids are passed during the day, still the distance traveled has been nearly six miles. About 3 p. m. a beautiful vista is passed, formed by the granite boulders that approach quite to the bed of the river, contracting the channel so as to produce an enormous current. The shifting current for quite a distance has sculptured strange contours among the granite walls that at this low stage protrude above the water. Many are carved like full columns, others honeycombed in extravagance of form, making the view in all its phases the grandest and most sublime of any noticed along the route. The channel here is the narrowest yet met—being less than 50 feet wide. The thickness of the granite beds becomes greater and greater, and now reaches from 700 to 800 feet. The more solid the granite the less dangerous and difficult the rapids and falls. This is easily explained, since the rapids have formed by accumulated debris breaking in from the side cañons, and from the boulders detaching from the sides of the main wall and falling into the stream. The latter more frequently make the dam, and the irregular flow of the water causes these most terrible rapids. It becomes necessary to make a very difficult portage just at dusk. It is very severe, since the men are greatly worn. The hope of ultimate success sustains the sinking courage as also the belief that no one will follow speedily in our tracks, thus making the ascending exploration of the river complete and final.

October 14.—At River Camp No. 26, above Portage Rapids. The temperature at night in the cañon has been of late decreasing, and the morning fire that can be made by a little drift-wood picked up is very agreeable. An old Indian trail is found in the creek that comes into the cañon from the south. There are a few hills of scanty corn of this season's growth, while a little avenue among the willows seems to have been planted with beans in hills, but no appearance of fruit. The Indians have evidently been here in the early spring, but not since. One of the worst rapids of the trip was met to-day, which obliged the portage of the boats with all the stores for fully one-fourth of a mile. Mr. Hamel and myself penetrated a second creek coming in from the south, following a gentler slope than any yet seen, which leads to the belief that possibly one could emerge by it from the cañon bed, if necessary. The distance to-day is 2¾ miles. It took six hours to pass the rapid above mentioned. This morning the rear boat picked up a duck floating down the stream that had been killed by a shot, and it is hoped this may indicate that the land party has reached the mouth of Diamond Creek, and that it is not far distant.

Camp is made at a southern bend of the river, and for the first time out of sight of a rapid. Now and then a stray duck is seen, but hardly any other winged animals. The flora of the side cañons is extremely meager. Their streams have no fish. A peculiar salmon and hunchback are found in the river at places, but being without hooks it has been impossible to increase the scanty stock of provisions. No new plants or other forms appear, and the entire cañon is but one grand rock laboratory. Noted to-day a small snake with black and white rings, different from any yet seen. Traveled 2¾ miles, approximately.

October 15.—River Camp No. 27, Castaway Rapids. After an inspection of provisions held this morning, it becomes necessary to further curtail the amounts allowed to each individual. A rapid is passed early in the day with a fall of 8.8 feet, at which point the river is 48½ feet in width. Eleven rapids are met and passed during the day, the entire distance gained being about 3¼ miles. The semi-granite walls appear on either hand with a superior cap of sandstone more prominent, giving at this special locality great perpendicularity to the walls. Towing is hence a thing very much to be dreaded. The short lengths of apparently smooth water are becoming less frequent, and swift currents are noted at each turn in the river. This indicates—and our aneroids verify the fact—that the fall per mile increases at every step.

Mr. Gilbert's boat is cast away in pulling through the last rapid, and he and Hecox go so far down the stream that the crew could not reach them, hence they go supperless to bed among the rocks in this wild cañon. Our camp is a little shelving place in the rocks, with scarcely room enough for the little party to sleep among the boulders. Everyone is gloomy at the prospect, starvation staring one in the face without the certainty of relief either in advance or retreat.

October 16.—Camp No. 28, Starvation Camp. To-day it has often been necessary to climb as high as 100 feet to pass the tow-rope ahead. Two portages of stores were necessary, and one portage of the boats. In passing the third nest of rapids the rope parted and one of the boats was cast away upon one of the roughest rapids in the river. The sight, although exciting, was an extremely sickening one. The boat was caught, however, on the other side, and extricated after much difficulty. Such accidents are disheartening in the face of the presumable dangers yet in advance, the number and extent of which are yet unknown. The boat upon the second trial, however, passed safely. Washes reach the river from either side at the head of this rapid, and hence the magnitude of the dam accounts for its length. The one from the north is a stream with about 200 inches flow; the one from the other direction has a very gentle slope.

Mr. Hamel climbed the granite wall, and reports it smooth and level on the top of the mesa. It may yet be necessary to take this route to the mouth of Diamond Creek. Astronomical observations were made for time and latitude. The entire rations of the party scarcely make a re-enforce to my blanket pillow, where they are at night placed as a precaution.

October 17.—Camp No. 29, below Concealed Rapids. Made a portage of boats to-day among the narrowest and heaviest rapids of the trip. Width 35 feet, fall 10⅒ feet. Speculations are rife to-day as to the prospect of either want and starvation and inability to get out of the cañon, and yet I believe there will be some loophole in event of the utmost emergency. Fortunately the weather during the day continues fine. The warm genial sun now and then reaches the river and improves the temperature of the water, with which all persons have constantly to deal, and the hands are not so cold that any of the party suffer in consequence. The river trip would still continue practicable were the unforeseen trials and privations known so as to be mastered. As it is, each day seems like an age, and the danger of complete disaster stares one so plainly in the face that a state of uneasiness naturally prevails. To day I have been thinking over a plan of sending forward upon the mesas to reach Diamond Creek. My mind is still bent upon taking the boats to their original destination if they will hold together. It has been necessary to guard the entire stock of rations in person for the last few days. It is decided this evening in the event of emergency that the boats shall be abandoned, the mesa reached on foot, and the mouth of Diamond Creek thus reached. Gained 3½ miles to-day. Saw the new moon by daylight, 2 p. m.

October 18.—River Camp No. 30, Look-ahead Camp. It is now hardly daylight until 7 o'clock, at which time the weary labors of the day are begun. A portage about 9 o'clock is effected at a rapid where some ugly boulders of enormous proportions are the only beach. To-day the fifth castaway is noted, and Gilbert and Salmon try their luck at swimming. It is estimated that the distance to the mouth of Diamond Creek cannot exceed 17 miles. The track of a man's foot with boots or shoes on is noted on the southern bank. It is hoped that it may be some one from the relief party. A longer portage of boats has to be made, but it proves successful, and the camp at night is so selected that it is believed the mesa in close proximity may be climbed in the morning. Notwithstanding the great obstacles of the day, a distance of 3¼ miles has been gained. The boats are leaking badly. Complete instructions are made for the two messengers, Hecox and Roberts, who volunteered to start out in the morning to reach Diamond Creek. This seems a necessary measure, as the lives of twenty persons are now dependent upon the success of the messengers sent ahead for food. A fair-sized loaf is cooked for each, and they will depart at daylight. Between 10 and 11 a. m. Mr. Gilbert saw plainly the planet Venus. Astronomical observations were here taken.

October 19.—Camp No. 31, mouth of Diamond Creek. The climb to the top of the first mesa is very steep, but it was pleasant to find that there was sufficient space to the rear to admit of a pretty level trail along the next series of bluffs. The messengers feel hopeful, and fully appreciate the necessity for vigorous efforts on their part. It is fully understood by them that the parties intend to abandon the boats and follow on their trail on the morning of the 22d, if no assistance is sent before then. There is a slight chance of their reaching Diamond Creek and bringing provisions back by the second night. If not there must be considerable suffering on the part of those left with the boats. At a mile a little creek is crossed, on which old fire beds show the presence of Indians in their hunting season. I attempted to explore the bed of the stream crossing into the river, and was obliged to climb to the lower mesas, narrowly escaping a fall of 150 feet. The cañon cut out by this stream is the most romantic I have ever examined among the varied scenes of years of mountain life. Shortly after, one of the members finds a fish-pole and line with a large salmon attached, which probably came from the party at the mouth of Diamond Creek, and a little later a float and message from Hecox, who had reached the mouth of Diamond Creek. About 2 p. m. a signal is seen, which proves to be a handkerchief left by Spencer, about 6 miles ahead, toward which all possible exertion is made, hoping to reach that point before sundown. Camp is reached before dark, not knowing until then how tired and weary all had become. Mr. Hamel reports having seen during the day a star at a point in the cañon where the upper walls were in close proximity. Sextant observations for time and latitude were here made, and also a cross-section of the river by Mr. Hamel.

Plate XXII was redrawn from a photograph taken in 1872 near the mouth of Kanab Wash, and shows some of the peculiarities of the erosion and the number of beds that make up the plateau system at this locality.

Plate XXIII gives an illustration of the verticality of the lower or first wall above the bed of the river, as also the carving of its surface at Paria Creek. A part of the summit of an irregular plateau appears in the distance.

Plate XXIV is a sketch redrawn from a photograph by O'Sullivan at the mouth of Diamond Creek, showing the northern wall of the cañon that is here eroded into gentler profiles. The parties (enumerated below) belonging to the two boats that reached this point occupy the foreground. The following persons made the entire river trip: (1) Lieutenant Wheeler, (2) P. W. Hamel, (3) G. K. Gilbert, (4) T. H, O'Sullivan, (5) E. M. Richardson, (6) Frank Hecox, (7) William George Salmon, (8) R. W. James, (9) Thomas Hoagland, (10) George Phifer, (11) William Roberts, (12) Privates Drew, Flynn, and Keegan, and six Mohave Indians (Panabona, Seliquirowa, Obehua, Havanata, Sowickopelia, and Mitziera), making twenty in all. The entire party worked with a will and were unflagging in their exertions, more especially those who were willing to continue the ascent after the third or damaged boat returned to the crossing. Mr. O'Sullivan, in the face of all obstacles, made negatives at all available points, some of which were saved, but the principal ones of the collections were ruined during transportation from Prescott, Ariz., via mouth of the Colorado, San Francisco, &c., to Washington, D. C., thus destroying one of the most unique sets of photographs ever taken.

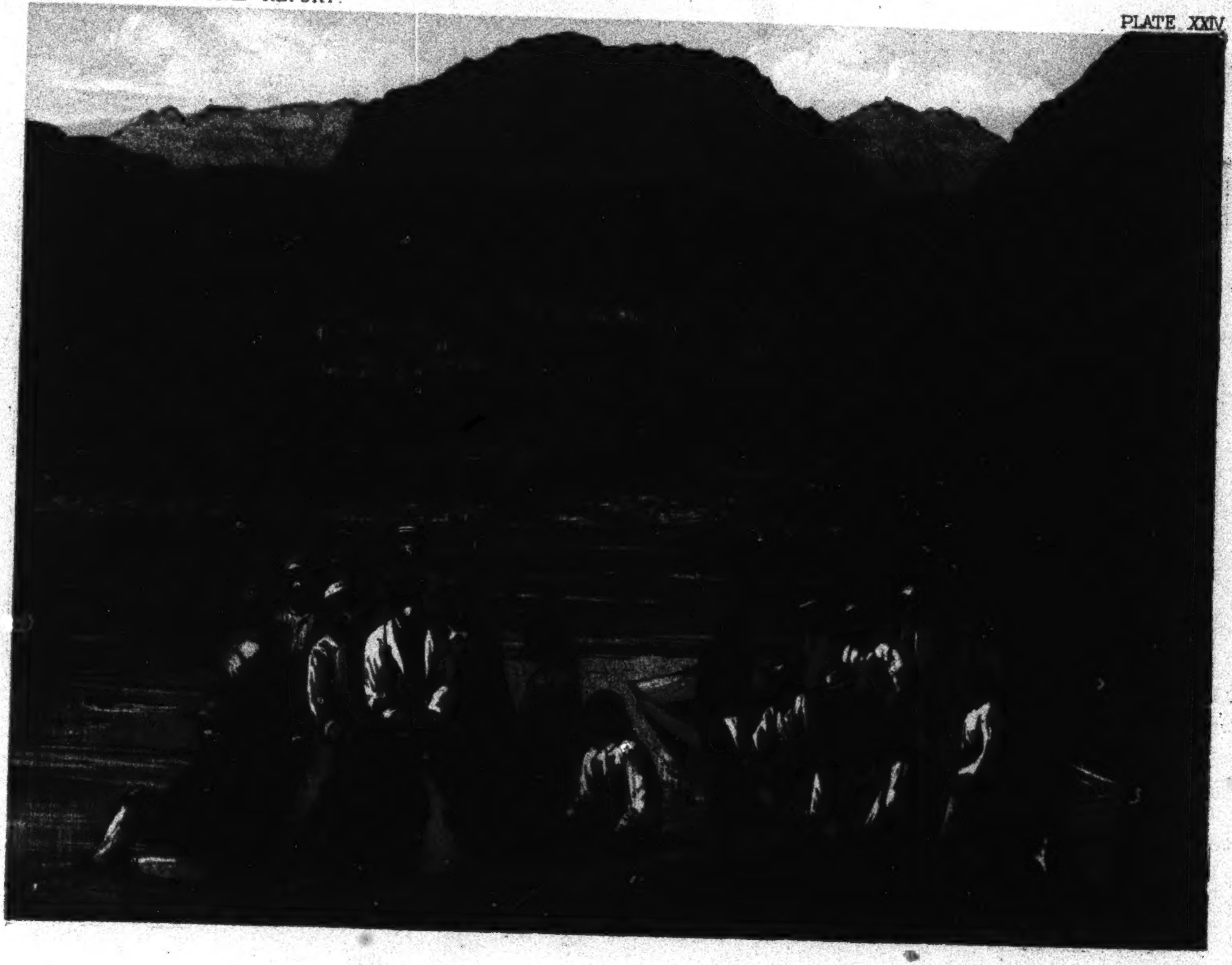
Observations for time and latitude were made by Lieutenant Lockwood and myself at the mouth of Diamond Creek. This same point had been reached by Ives during his land trip eastward to Fort Defiance. The relief party is overhauled at Peach Tree Spring by the advance runners, and they and a fresh relief party from the rendezvous at Truxton Springs reach the river on the 20th, bringing mental comfort and rations. A number of the boat party proceed the 21st to join the rendezvous, while

GRAND CAÑON OF THE COLORADO RIVER,
NEAR MOUTH OF THE KANAB WASH, LOOKING EAST.
1872.

GRAND CANON OF THE COLORADO, NEAR PARIA CREEK, LOOKING EAST.

1872.

PLATE XXIV.



COLORADO RIVER PARTY REACHING MOUTH OF DIAMOND CREEK.

1871.

the balance begin their perilous journey down-stream, joining the barge and continuing the descent to Mohave, which point was reached in safety on the evening of the fifth day, thus evidencing the difference in rate of travel whether with or against the current.

The transfer of the land parties to the south to the selected point of rendezvous, through a section almost a desert waste, without water and a *terra incognita*, the successful junction of the river and land divisions, and the accomplishment of the duties laid out for the different parties at the specified times was a masterpiece of successful exploring, and shows the admirable will and energy of all parties of the command. The guide, Charles Spencer, contributed in no small degree to the harmonious working of the plan, and to his intimate knowledge of the country was due the certainty as to date of connecting forces.

The river at Camp Mohave on September 15, 1871, was found by Mr. P. W. Hamel to have a mean velocity of 3.006 feet, and a volume of discharge of 16.232 cubic feet per second. The observations were taken along a profile of 870 feet in width and cross-section of 5.400 square feet. Lieutenant Bergland, on September 3, 1875, found a mean velocity of 1.25 feet near the same point, a discharge of 11,611 cubic feet through a cross-section of 4,628 feet, the width being 1,116 feet. The above observations can alone be reconciled in view of the sudden rises of the river from violent mid-summer rains near the sources of the Green and Grand and the Little Colorado. There local floods, having their source at great altitudes, are of short duration, and their influence will be felt but for a few days at any point along the stream, and hence the observations at intervals of not more than ten days may not properly be comparable or bear a fixed ratio to the mean flow. Soundings from 14 to 28 feet were noted in the river channel at foot of Boulder Cañon. At Stone's Ferry, on August 11, 1875, Lieutenant Bergland found a flow of 18,410 cubic feet per second through an orifice of 5.723 square feet, the width being 480 feet. The cross-section at foot of Grand Cañon was 2,610 square feet, the width 315 feet, and soundings were recorded from 3 to 20 feet. At mouth of Diamond Creek the width was found to be 280 feet, and soundings noted from 9 to 30 feet.

One of the results of the river exploration has been to determine the absolute limit of navigation, a question not settled by the exploration of Ives, as a steamer ascended the river to a point (Callville) a short distance beyond the uppermost point reached by him in his boat. This limit is the foot of the Grand Cañon, or near the crossing of 1871.

It is certain that at no stage of water could steamers reach this point unless the channel shall be improved by the removal of sunken rocks; but no insurmountable obstacles of this nature exist. The furthest practical head of improved navigation must remain permanently at the foot of the Grand Cañon.

The exploration of the Colorado River may now be considered complete. Its course has been traced from its mouth to the junction of the Green and Grand, and the positions of incoming tributaries noted. The greater part of the basins of the Grand and Green have undergone quite thorough exploration and survey during the past ten years, as well as much of the Great Colorado Plateau that borders the river in the vicinity of the great cañons.

These stupendous specimens of extended rock-carving that make up the system of the cañons have been partially described and made known. They stand without a known rival upon the face of the globe, must always remain one of the wonders, and will, as circumstances of transportation permit, attract the denizens of all quarters of the world who in their travels delight to gaze upon the intricacies of nature.

MAP.

The special map, on a scale of 1 inch to 6 miles, accompanying this report shows, besides the line of the river from Camp Mohave to the mouth of Diamond Creek and beyond, a number of the routes of the contiguous land parties, and locates by careful projection for the first time this little-known part of the river and its vicinity, embracing original detailed topography not elsewhere published. Each camp is marked so that the position stated in the text can be readily found. The western edge of this portion of the Colorado Plateau, a name proposed by myself for this class of elevated mountainous structures bordering more especially upon the Grand

Cañon region of the Colorado and embracing portions of Southeastern Utah, Northern and Northeastern Arizona, extreme Northwest New Mexico, and extreme Southwest Colorado, is made distinct. The abrupt bend to the south is a marked feature, and the truly cañon features of the river as far as Mohave are shown. The Atlantic and Pacific Railroad now (1886) traverses the southeastern quarter, passing Truxton and Beale Springs. The field-notes of the cañon proper were plotted on a large scale, which alone can show something of its intricacy and grandeur.

GEOLOGICAL SECTIONS.

The "Aubrey group" of the Carboniferous at the mouth of the Grand Cañon, according to G. K. Gilbert (see Vol. III), is made up of approximately 200 feet of cherty limestones, 300 feet cross-bedded yellow sandstones, massive, 800 feet red and white shales and sandstones. The "Red Wall group" of the same formation consists of 510 feet of alternating sandstones and compact limestones, 800 feet red wall limestone (sheer escarpment), 1,365 feet limestones with intermediate calcareous shales. The "Tonto group" of the Lower Silurian is made up of 75 feet of marbled limestone, 600 feet of argillaceous shales with thin sandstones, mostly red, 80 feet dark red sandstone, heavy bedded, and of 90 feet of granite, &c., to river of the Archæan.

Mr. Gilbert gives the following geological section at the mouth of Diamond Creek: Granite and overlying schists at the base; then succeeding the "Tonto group" composed of sandstone, shale, and limestone; the red wall bed of limestone; then Aubrey sandstones and limestones (see page 69, Vol. III, Geographical Surveys).

The geological formations along the river route were observed as far as practicable by G. K. Gilbert. The topography gathered by Mr. P. W. Hamel in the midst of so many obstacles, is but an attestation of his skill in this direction made manifest in all his former duties under me. With one accord the river party were faithful to their duties and trusts, and by hearty action rendered the river ascent so great a success.

CHAPTER III.

POPULATION, INDUSTRIES, COMMUNICATIONS, IRRIGATION, AND ARTESIAN WELLS.

POPULATION.

The scene of operations was purposely laid in regions the most remote from local centers of settlement, the latter being availed of purely for outfitting, rendezvous, and supply.

The attempt has been made to tabulate the population so far as the published details of the ninth and tenth censuses will allow, with the following result:

TABLE OF CERTAIN AREAS WEST OF THE 100TH MERIDIAN, WITH ACTUAL AND RELATIVE POPULATION.

[Computed and estimated from ninth and tenth censuses.]

Locality.	Total area.	Total population, 1870.	Per square mile, 1870.	Total population, 1880.	Per square mile, 1880.	Area surveyed.*	Population in surveyed area, 1870.	Per square mile.	Population in surveyed area, 1880.	Per square mile.	Per cent. increase in 10 years for all.	Per cent. increase in surveyed area for 10 years.
	Sq. miles.					Sq. miles.						
Arizona	113,929	9,658	0.09	40,440	0.36	61,816	7,371	0.12	28,682	0.47	300	292
California	158,360	560,247	3.54	864,694	5.46	64,906	103,200	1.59	148,591	2.29	54	44
Colorado	103,925	39,864	0.38	194,327	1.87	34,283	28,786	0.83	125,613	3.66	392	330
Idaho	84,800	14,999	0.18	32,610	0.38	8,677	1,822	0.21	8,820	0.99	111	371
Nevada	110,700	42,491	0.38	62,266	0.56	62,161	18,053	0.29	53,370	0.86	47	195
New Mexico	122,580	91,874	0.74	119,565	0.97	80,032	84,207	1.05	117,610	1.47	31	40
Oregon	96,030	90,923	0.95	174,768	1.82	7,000	5,614	0.74	12,834	1.83	92	147
Utah	84,970	86,786	1.02	143,963	1.69	39,809	51,285	1.31	124,245	3.44	65	153
Total	874,385	936,842	1.07	1,632,633	1.87	358,684	302,205	0.84	621,067	1.76	75	106

*NOTE.—These are the areas for which it has been possible to compute or estimate population.

The area of 358,684 square miles out of a total of 359,065 square miles surveyed contained in 1870 (as near as may be ascertained from the census tables) 302,205 white inhabitants, of which 103,200 belonged to California, 84,200 to New Mexico, and the balance to other States and Territories.

This number increased to that of 631,067 (approximated) during the succeeding ten years.

From the foregoing table it appears that the largest per capita of population of the political divisions tabulated was 3.54 per square mile for California in 1870 and 5.46 in 1880, with a minimum of 0.09 per square mile for Arizona in 1870 and 0.36 for 1880 (also Arizona), while the largest pro rata in the areas surveyed, according to political divisions, was 1.59 per square mile for California in 1870 and 3.66 per square mile for Colorado in 1880.

In case of the areas surveyed the average per square mile is but little increased, on account of comparatively large towns, except Leadville for Colorado; hence the larger share belong to the productive class, whether as miners, agriculturists, or stock growers, and not to the middle and non-productive classes, who are consumers only.

In case of each political division the increase for 10 years (1870–1880) is at a greater ratio for the surveyed area as compared with the total area of the State or Territory, which indicates the occupation of virgin lands, and is a sign of a healthy development, no little part of which, it is believed, has been due to the fact that the knowledge, gained by the Government expeditions and surveys has been disseminated far and wide through published maps and reports, official and otherwise.

The probable future agricultural population of the area surveyed (359,065 square miles), taken as a whole, will be governed as much, if not more, by the permanent supply of water than by the acreage available, for nearly all requires irrigation to be productive, and the most superficial estimate shows a tremendous deficit in water, as compared with the amount actually required (governed by known moduli) to irrigate alone the valleys, plains, and comparatively level foot-hills.

Hence, in the aggregate, the waters of the western mountain region represent a large relative wealth, yet but little developed, while the present laws admit of practical, if not permanent, alienation of the water from the land.

No wiser move could be made in the future of the land question than to have a critical measurement of all the principal means of water supply made and recorded for the use of the Government and people.

The average percentage of arable land for about 175,000 square miles, classified, was found to be 5, which applied to the whole surveyed area, and at the rate of 200 inhabitants to the square mile, gives an estimate of 3,500,000 for the farming industry, which can easily be increased to a limit of not less than 15,000,000 for all classes of inhabitants (only 16.95 per cent found arid for 175,000 square miles) connected with mining, stock raising, manufactures, and commerce.

While any estimate is largely conjectural, yet the population for mining alone, which is not limited by the area mined, as supplies can be almost entirely imported, may be enlarged indefinitely, pursuant to the fixed and intelligent search for the precious metals, and the development of the economic minerals, constantly being made available through improved means of transportation for the demands of an increasing population, the center of which moves steadily westward.

The character, disposition, and peculiarities of the moving and fixed population that has taken possession of the Pacific coast and interior during the past 40 years is well known to every one, but not so that of the Mormons, who occupy and control a large meridional area about midway between the plains and the Pacific.

The survey covered substantially all the area over which these people have spread, and it falls within the scope of the observations made to record certain data bearing thereupon.

The area of the survey has embraced nearly all the territory occupied by this people in Utah, a part of the settlements in Idaho, and all those formerly in Southeastern Nevada. The total number of towns, villages, and settlements entered from 1869 to 1878 was 182, of which 145 belong to Utah, 23 to Idaho, and 11 to Nevada. Of these 107 were visited personally. The total population of Utah according to the census of 1880 was 143,963, while it appears that the number within the surveyed area is, approximately, 134,245, which includes none for Morgan, San Juan, Emery, and Uintah counties. The population, as per census of 1880, of the 23 Idaho towns above mentioned was not less than 8,829, making a total population in 1880 for 168 places (Mormons and Gentiles) of not less than 143,074, independent of Mormon residents remaining in Nevada.

The actual number of Mormons is not particularized in the census report, but each of the towns referred to is a Mormon town in the sense of being controlled by the dual, or church and state, authority of this modern religious hierarchy.

New settlements have sprung up in Arizona, New Mexico, and Wyoming since the expedition visited the localities in these political divisions now appropriated by the Mormons, while 11 of their southwestern settlements that fell within Nevada when the boundary was run in 1870 were brought back to Utah since it was alleged that taxes were higher in Nevada and the State law against polygamy could doubtless have been enforced.

The probable Mormon population in the western Territories did not, as it would appear, exceed 150,000 in 1880, which number is increased by emigration not less than 1,000 annually, and by the excess of births over deaths. This population, beginning with an American nucleus, has been recruited principally from the manufacturing and commercial centers of Great Britain, Denmark, the Scandinavian regions, Switzerland, and Germany, and usually from a mentally low and uneducated class, naturally willing to adopt any new scheme of religion, especially when coupled with proffers of an open air, healthy home, with promise of land to live upon, and a loan or donation of agricultural implements and seeds as an adjunct thereto.

It appears that the following order of succession in authority prevails in the church organization: (1) president; (2) presidency of three; (3) twelve apostles; (4) the seventy (special); (5) elders; (6) priests; (7) teachers; (8) deacons; (9) bishops (judges); and (10) ordinary or lay members.

It is believed that this organization, admitting as it does of providing a place with some authority attached to it for each person of sufficient mental ability, has been so far perfected that the actions, if need be, of each man, woman, and child to the greatest detail can be observed and carried, when necessary, direct to the main president.

The church was organized by Joseph Smith, the first president, in 1830, in Manchester, N. Y. The succeeding presidents have been Brigham Young and John Taylor (lately deceased).[*]

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[*] At date of proof-reading (August 10, 1887) the office is vacant.

The tithing house is one of their principal institutions; it is the receptacle for one-tenth of all the income and earning of each individual, and the amount is devoted to the uses and purposes of the Lord through the needs of the church.

Agriculture is with them the predominant industry, and they are, with very few exceptions, provident, industrious, and thrifty.

Mining for the precious metals has always been looked upon with suspicion, as a disturbing element to the true interest and progress of the community, while manufactures on a limited scale where skilled mechanical labor has been available have been prosecuted successfully in several of the larger towns. In every town that has been settled from fifteen to twenty years I have been favorably impressed with the quiet and orderly demeanor of the inhabitants, the cleanliness and substantial nature of their dwellings, and a spirit of contentment based on a willing industry that would do credit to any community in any quarter of the globe. The meeting-houses, to be sure, predominate in numbers, and often to the exclusion of the schoolhouse, and in many of the outer settlements, especially, some of the children appeared lawless, unkempt, and untaught.

They claim, and it is believed with justice, that their communities are without abandoned women, doctors, or lawyers. The practice of polygamy is cited as the reason for the first, the old women attend to the second, and the bishops and other officials are both lawyer and judge.

The "spiritual wife" system, or practice of polygamy, which conflicts with and is contrary to the laws of modern civilization, was only "revealed" to Joseph Smith about 1841–'42, and was at first, at least, confined principally to the high priests and chiefs of the hierarchy. The practice, resulting from this so-called revelation, acts as a powerful secular instrument by which to hold the communities together.

Lieutenant Gunnison, in his history of the Mormons published in 1852, presents his views of causes that may operate to defeat the practice of polygamy within the church itself.

The greatest benefits that could possibly obtain for these people, now alienated from the balance of the civilized world, would be the extirpation of polygamy by a means which shall render adults renouncing the practice not liable, the present polygamous offspring legally legitimate, and the church corporation restricted to the ownership only of such lands and improvements as are needed for strictly religious uses.

Contact with "Gentiles," so called, making for themselves permanent homes in all the region now occupied by the Mormons, the introduction of Christian schools and other religious teachings, will help to emancipate this community that has sought a habitation within our border.

INDUSTRIES.

Mining is more or less general for the whole area, while farming or ranching is the exception for all other divisions than Utah. Some idea of the agricultural production of the region surveyed may be had from the following table compiled from the Tenth Census:

TABLES SHOWING FARM AND LIVE STOCK PRODUCTION FOR AREA SURVEYED WEST OF 100TH MERIDIAN (CENSUS OF 1880).

States and Territories.	Farms.	Improved land.	Estimated value of all farm production, 1879.	Horses, mules, asses, and oxen.	Cattle.	Sheep.	Wool.	Swine.
	Number.	*Acres.*	*Dollars.*	*Number.*	*Number.*	*Number.*	*Pounds.*	*Number.*
Arizona	501	40,211	449,710	5,836	33,600	76,506	313,674	1,012
California	7,101	1,121,963	7,824,411	54,502	158,208	1,106,373	4,919,201	156,909
Colorado	2,051	364,016	2,753,814	57,004	344,774	745,548	3,195,091	7,165
Idaho	591	41,752	170,180	4,980	16,570	5,675	22,635	902
Nevada	1,126	241,470	2,296,007	29,062	96,032	105,730	495,859	5,351
New Mexico	4,902	232,371	1,890,225	37,351	123,601	1,636,823	3,350,298	5,980
Oregon	1,987	184,561	1,411,041	27,365	79,344	312,299	1,705,470	24,725
Utah	8,941	393,603	3,962,040	42,645	95,173	106,255	747,768	15,909
Total	27,900	2,619,285	19,847,328	249,785	947,447	4,298,313	14,949,327	217,873

NOTE.—The counties embraced, in whole or in part, are as follows: *Arizona:* Graham, Apache, Gila, Yavapai, Mohave, Yuma, Pinal, and Pima (two-thirds). *California:* Plumas, Alpine, Tuolumne, Mono, Mariposa, Inyo, Kern, San Bernardino, Los Angeles, Tulare (two thirds), Calaveras (one-half), El Dorado (one-half), Lassen (one-half), San Diego (one-sixth), Shasta (one-seventh), Tehama (one-third), Butte (one-sixth), Sierra (one-half), Nevada (one-third), Placer (one-third), Amador (one-third), Merced (one-eighth), and Fresno (one-third). *Colorado:* Jefferson, Douglas, El Paso, Pueblo, Huerfano, Costilla, Rio Grande, Conejos, La Plata, San Juan, Ouray, Saguache, Gunnison, Carter, Fremont, Lake, Park, Summit, Clear Creek, Gilpin, Arapahoe, Bent, Boulder, Larimer, Las Animas, and Weld. *Idaho:* Bear Lake, Oneida. *Nevada:* Washoe, Storey, Ormsby, Lyon, Douglas, Esmeralda, Nye, Lincoln, White Pine, Churchill, Roop, Eureka, Lander, and Elko (one-tenth). *New Mexico:* Doña Ana, Grant, Socorro, Valencia, Santa Fe, Rio Arriba, Taos, Bernalillo, Colfax (four-fifths), Mora (four-fifths), San Miguel (four-fifths), and Lincoln (four-fifths). *Oregon:* Lake, Wasco, and Washington. *Utah:* Cache, Rich, Weber, Davis, Box Elder, Tooele, Utah, Wasatch, Juab, Millard, San Pete, Sevier, Beaver, Piute, Iron, Salt Lake (seven-eighths), Kane, Washington, and Summit (one-half).

The relative amount of the whole area surveyed being farmed in 1880 appears to be about 1.1 per cent, with 2.7 per cent. for California, 1.5 per cent. for each Colorado and Utah, and less for all the others. It should be remarked that the regions are among the least settled, more inhospitable and remote than all others of the Western mountain region. The largest number of cattle per square mile are found in Colorado, and the least in Arizona, the most sheep in New Mexico, wool in California, and the least pro rata of sheep and wool in Idaho. The limit of the possibilities for all kinds of live stock is yet far distant.

Agriculture can never be general for the territory surveyed, but must be confined to the narrow valleys, plains, and glade-like spaces, and lower levels of the foot-hills bordering on the streams, irrigation in nearly every instance being imperative on account of climatic conditions, orographical features, and especially insufficient and variable rainfall. In minor localities where the average rainfall is sufficient crops mature without it, its amount being limited both by small relative percentage of arable land, and the scarcity of water defining the area that may be reclaimed.*

Hence this industry must forever, in this section, be subordinate to others, principally mining, and in case of the full development of the latter food supplies will be a permanent import.

A timbered area of about 27 per cent. was found for 175.000 square miles, examined and noted.†

This is much larger than would have been found for the whole area (359,065 square miles), as portions not determined belong to the more desert tracts, especially of Eastern and Southeastern California and Southwestern Nevada, where scarcely any timber is found, and it may be assumed that this percentage is much greater than that for the whole territory south of the 40th parallel. Hence it would appear that the relative amount is small, not so much for the local supply for long periods, but for the requirements upon it to be made by the Mississippi Valley region, if not the East, when the northern forests are exhausted, in the near future.

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* NOTE.—Nothing short of the exact gauging of streams and other sources of supply and of contiguous fields available for irrigation, making due allowance for returning water to its former channel after uses in irrigation, and allowing for absorption and evaporation while in transit, and applying a proper water modulus of, say, 1 cubic foot per second for each 200 acres, will give any adequate idea of the amount of land that may be ultimately and permanently tilled.

† NOTE.—Dr. Rothrock gives in a table on page 33, Volume VI, the proportionate area of wooded to open ground in Colorado, Utah, New Mexico, Arizona, Nevada, California, Texas, Kansas, and Nebraska, as 86,793,670 acres wooded in a total of 740,373,523 acres, or 11.7 per cent.

The greater share of the timber being coniferous, indicates that nature will not readily replenish the depletions when made, as is the case for deciduous growths.

It is clear that the preservation of these forest areas cannot be guarded with too great solicitude.

While all of the relations of the forests to climates are not yet fully determinate, yet it is well known that they establish more uniform or equable climatic conditions, tempering, as they do, the extremes of wet and dry, heat and cold.*

While the permanent official control of these forest areas may not be possible, as the Government does not hold in perpetuity, yet the laws governing the disposition of the remaining public lands to settlers may be made such as to determine their segregation into the hands of small holders, the timber may be protected from destruction until Government patents issue, while, finally, individual States may govern through statutes looking to the minimum of spoliation and the maximum of replanting, or to the conservation and extension of existing forests.

First of all, these areas must be protected from fires (the most destructive factor), which, whether accidental or intentional, injure the large trees and kill the young growth.†

The browsing of animals is a considerable source of destruction.

The law should not permit cutting under a certain size; as, for instance, the yellow pine (*Pinus ponderosa*) should not have a diameter of less than

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*NOTE.—As a general result from scientific investigation at meteorological stations in Germany, France, Switzerland, and Italy it has been found that during the warmer season (1) the air and earth temperatures were lower in the forest than in contiguous woodless places; (2) their variations less; and (3) the relative humidity was greater. (See Woeikof on the influence of forests upon climate. Petermann's Mittheilungen, 1885. No. 3.)

†NOTE.—Professor Sargent gives in Volume IX, Tenth Census, the aggregate of about 750,000 acres burned over in 1880, in the eight divisions given in the preceding table.

12 inches at 20 feet above ground. No trees should be cut solely for lumber, as the tops are left to rot. Where trees are removed for lumber others should be planted.

Dr. Rothrock recommends for this purpose: (1) Removal of the Indians; (2) affixing a severe penalty in case of conviction of setting fire; (3) removing sheep from timbered areas.

The Swedish law (enacted prior to 1647) compels the "private owner to plant and protect from cattle two timber trees for every one cut."

Dr. Rothrock is of the opinion that with care and reasonable expense, areas denuded of timber may be regrown.*

There is not the same necessity for the protection of pine as for all other species, including conifers, junipers, oaks, walnut, &c. Heavily timbered areas will be of great advantage, especially in decreasing evaporation in vicinity of tanks, that will be required as a part of future irrigating systems.

While the law should limit the present waste, there never need be a time when the removal of forests for legitimate purposes shall cease. Dr. Rothrock is of the opinion that there are thousands of acres in Arizona where the blue gum and the western catalpa (both valuable hard woods of rapid growth) may be planted. He says:

> It may fairly become a question as to whether it would not be money well invested if the General and State governments were to anticipate future wants, and plant extensive areas of our Western domain with hardy and rapidly growing timber trees.
>
> It appears from the latest statistical information available that already the States and Territories comprising our domain are, in the percentage of timber area to the entire surface, actually below Norway, Sweden, Russia, and Germany.

Since the above was written (1878) the deforestation, especially in the conifer regions, has been going on at an ever-increasing rate. The proportionate grazing area for 175,000 square miles, where data were computed, is found to be 49.37 per cent. This is probably larger than the average for the whole western mountain area, but points to this industry as one relatively large, and which in the increasing volume of population will naturally be carried to a maximum. To this end the water must be husbanded, and indeed much of the area possessed of natural perennial grasses cannot now or ever be utilized for want of water for the stock.

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*NOTE.—It is not by any means certain that the natural regrowth will not exceed the amount necessary for ordinary industrial uses, except for the coniferous areas. In deciduous forests it is economy when trees have reached their prime that they be cut rather than left to rot, others taking their places.

Independent of the conservation of the present sources of supply, an increase may be had at selected points through artesian wells, and a better distribution through a system of reservoirs and tanks. A prior table gives 249,785 as the number of horses, mules, asses, and oxen for surveyed area in 1880, with 947,447 cattle, 4,200,313 sheep, 214,873 swine, and an annual production of 14,649,327 pounds of wool

Stock-raising has become already a fixed and settled industry in which much capital is invested and wherein business skill and enterprise will ultimately cover the whole field of our western possessions.

The question of the utilization of grazing areas without water must soon come up for action, as no existing land law is adequate to their free appropriation by the actual settler. About 17 per cent. of an area of 175,000 square miles examined for land classification was found to be absolutely barren. The total percentage for the whole western mountain region of about 1,000,000, although it includes the "Great Interior Basin" and "Desert," so called, will probably be less than the above, not exceeding 10 to 12 per cent. The misleading term "arid region" has been applied theoretically to territory west of the Mississippi, embracing more than four-tenths of the entire country, excluding Alaska, and the assumption made that only about 3 per cent. of this area can be used for agriculture through irrigation.

Actual observations (which so often explode theories) for 175,000 square miles adjacent to, bordering upon, and within the most desert, barren, and sterile wastes give a much larger percentage. The plentiful fields of the more productive and favored parts of California, Oregon, and Washington, especially, do not enter into this calculation, nor large tillable areas in Central Montana, all of which would largely add to the proportionate area finally available for agriculture, with present known sources of water supply. The present desert-land act provides for reclaiming portions of these areas fit for cultivation, when irrigated, but there will yet remain large tracts substantially desert and mountainous, worthless for the usual industries of agriculture, including grazing, timber growing, and mining, which if availed of at all permanently by settlers must be done by making the subdivision tracts larger and the rates nominal. These might be termed barren lands, and described as including all those sterile lands, whether of the mountains, the plains, or the valleys, not including those known to the law at present as "mineral," "timber and stone," "saline," "town-site," "desert," "coal," or as agricultural lands. These should be determined by a practical classification and marking out on the ground in advance of the legislation for their disposition.

Mining for the area in question has been carried on principally for the precious metals (gold and silver). The prominent districts of Washoe (Comstock Lode), Bodie, Cerro Gordo, Eureka, Austin, White Pine, Little Cottonwood, Pinal, Leadville, Rosita, and the San Juan fall within the area surveyed. These, when coupled with the Black Hills of Nebraska, Tombstone of Arizona, and Wood River district of Idaho, include the districts that have been the principal producers of gold and silver bullion from 1869 to 1879, inclusive, with the exception of certain of the gold mines (Lode and Placer) of California and the silver deposits of Central Colorado.

The expedition of 1869 took the field during the White Pine excitement, since which a roving mining population has superficially prospected, far and wide, developing hundreds of centers where concentrations of the precious metals have been found partially exposed. Many of these have been exploited, a few systematically, the greater number sporadically, or in a desultory way.

So far as time and means would permit, consistent with the aims of a topographic and geographic survey, it was the intention to follow in a general way this mining development, hence a "List of questions" was prepared (see Prel. Rept., 1871, p. 32), and information based upon them has been gathered at 219 separate localities or mining districts. In this manner specific information was obtained, particularly with regard to discovery, time worked, exterior communication, boundaries, area of croppings, relation of ledges to mountain structure, direction and extent of lodes and deposits, character of wall and country rock, nature of ores, results of assays and milling, annual production, number of mills, cost of mining, milling, labor, supplies, &c.*

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*There were on March 20, 1880, 804 districts wherein subdivision surveys by the and office had been made or were in progress. Mr. King, in "Statistics of the production of the precious metals," Tenth Census, gives a condensed estimate of the

The following, relating to the world's annual production, is taken from the Tenth Census:

A.—ANNUAL BULLION PRODUCT OF THE WORLD.*

POLITICAL DISTRIBUTION.

Country.	Gold.	Silver.	Total.
	Dollars.	*Dollars.*	*Dollars.*
United States †	33,379,663	41,110,957	74,490,620
Mexico	959,161	25,167,763	26,126,924
British Columbia ‡	910,804		910,804
Africa §	1,993,800		1,993,800
Argentine Republic	78,546	420,225	498,771
Colombia	4,000,000	1,000,000	5,000,000
Rest of South America §	1,993,800	1,029,190	3,022,990
Australia ‖	29,018,223		29,018,223
Austria	1,062,031	2,602,727	3,664,758
Germany ‖	205,361	6,938,073	7,143,434
Norway		108,270	108,270
Italy ‖	72,375	17,949	90,324
Russia ‖	26,584,000	415,676	26,999,676
Sweden	1,994	62,435	64,429
Rest of Europe		2,078,260	2,078,260
Japan	406,548	916,400	1,322,948
Total	100,756,306	81,336,045	182,092,351

* Table CC, Vol. XIII, Tenth Census, p. 381. † Census of 1880. ‡ Actual export. § From Dr. Soetbeer's estimate in 1875. ‖ Estimated from production of other years.

CONTINENTAL DISTRIBUTION.

Continent.	Total bullion product.	Percentage of total product.
	Dollars.	*Per cent.*
North America	101,528,348	55.76
Africa	1,993,800	1.10
Australia	29,018,223	15.92
Europe, including Russia in Asia	39,607,271	21.75
Japan	1,322,948	0.73
South America	8,521,761	4.68
Total	182,092,351	100.00

production of the precious metals in the United States from 1848 to 1880, by fiscal years, from reports of the Hon. H. C. Burchard, Director of the Mint, showing a total of gold of $1,520,041,532; silver, $460,422,260, or $1,980,463,792 for both. The greatest gold production for any single year after 1849 was $65,000,000, for 1853; and the least, $33,467,856, for 1875. The largest annual silver yield appears as $51,600,000, for 1885; while in 1878, the largest output of gold and silver (yet recorded), a total of $96,487,745 occurred. The total output from 1804 to December 13, 1885 (81 years), is stated (p. 204, Mineral Resources, 1885) at $1,708,715,670 for gold; $722,283,217 for silver; total, $2,430,998,887.

Illness, lack of time, and want of assistance has prevented the systematic presentation of the data thus collected, which more properly belongs to an office created for a special purpose than to one conducting a general topographic survey of the country.

Mention of these several districts will be found under the heading "Description of Maps."

The following table serves to exhibit a general view of the production of gold and silver in the territory surveyed, and demonstrates the great excess of the mining over the farming production at the present stage of development of this region.

TABLE INDICATING THE ESTIMATED VALUE OF GOLD AND SILVER CRES PRODUCED IN SURVEY AREA FOR YEAR ENDING MAY 31, 1880.*

State or Territory.	Ore raised.	Gold.	Silver.	Total.
	Tons.	*Dollars.*	*Dollars.*	*Dollars.*
Arizona	39,704	262,872	2,813,055	3,075,927
California	509,033	9,829,348	1,525,240	11,354,588
Colorado	348,492	2,683,923	19,306,006	21,989,929
Idaho	500	12,500	....	12,500
Nevada	343,272	5,466,382	14,069,610	19,535,992
New Mexico	10,486	86,776	774,533	861,309
Oregon	....	....	....	....
Utah	154,648	270,563	6,165,525	6,436,088
Total	1,297,825	18,562,264	44,654,049	63,216,313

The greatest production of gold and silver from a single district has been the output of the Comstock lode, estimated at $305,779,612.48, to June 30, 1880 (an average of five estimates, see p. 417.—"Lord, Comstock, Mining and Miners.")

The "great bonanzas," consisting of substantially connected ore bodies and found in the Consolidated Virginia, California, and Ophir ground, had yielded $107,000,000 up to the close of 1877 (see Church, Comstock Lode, p. 111). In 1880 California was the largest producer both of deep mine and placer gold, while Colorado was in the lead as to silver, with Nevada second. In the aggregate production Colorado was first, California second, and Nevada third.*

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*NOTE.—The estimated placer production for same area during same period is $1,788,168, of which $1,565,223 belongs to California. The total bullion output west of the Mississippi for same period is estimated, gold, $33,140,017; silver, $41,061,371; total, $74,201,388. The total bullion output for the above States and Territories for same period is $65,953,753. (See Tenth Census.) The total bullion output for the year 1870 is given at $66,000,000, of which $56,275,000 was divided from the above political divisions. (See Raymond Mining Statistics.) The mint authorities estimate the value of the gold produced in 1885 at $31,801,000, the silver at $51,600,000, total, $83,401,000. (See Mining Resources.)

There has been a slight falling off in the gold production of California for the five years ending 1885, a substantially uniform production of silver in Colorado, and a slight decline in the aggregated metals for Nevada in 1882 and 1883, a large increase in Montana, especially in 1885, and a general increase elsewhere in the Western States and Territories for the same period.

In smaller districts the reduction of ores (a truly separate business) takes place in favorable adjacent locations, either as an adjunct to the mining company or property, or as a separate ownership, the latter for all large districts. It may be noted that the output of complex silver ores has led to the centralization of reduction works, as evidenced at Argo, Boulder, and Pueblo, in Colorado, which, as transportation improves, will become more prominent.

The present status of the gold and silver industry of this region amounts to an increasing annual production, now exceeding $80,000,000, which bids fair to still further increase, in view of developments and production in new localities exceeding a deficit in older-established districts.

Hence the outlook is and has been encouraging, and especially as business methods and conservatism replace the irregular results of former wild speculations.

At least one-third of the world's current production of gold and one-half that of silver comes from the mines of the United States. While mining for the precious metals in the United States has not in so large a proportion of cases been a source of profit individually, yet it is believed by many that it has been so in the aggregate; the bullion products represent labor and are comparatively indestructible. It adds to the world's wealth, stimulates other industries, and adds to the ordinary increase of population, which latter sympathizes with healthful, equable production.

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* NOTE.—In 1885 California was first in gold production, with Colorado leading for silver, with Montana second, Utah third, and Nevada fourth; with Colorado first, California second, Montana third, and Nevada fourth, in the aggregate of gold and silver. In general, it may be said that the three States above mentioned have produced thus far the greater share of the gold and silver of the mines west of the 100th meridian.

The New Almaden Quicksilver Mines, so long well known in mining literature, came within the area under observation. These mines have been the greatest producers of mercury on our continent, and their output largely governed, for a time, the condition of this industry, now considerably depressed on account of the somewhat irregular demand.

The lead product is the result of the reduction of this metal found in connection with the argentiferous galena ores (carbonates and sulphurets), one great center of which is at Leadville.

Of the 139,897 short tons of lead estimated as produced in 1884, it appears that 112,965 tons was mined in Utah, Nevada, Colorado, Idaho, New Mexico, Arizona, and California, with Colorado leading at 63,165 tons.

The principal copper mines falling within the area of survey are those of the well-known Santa Rita district, in New Mexico; the Aztec and Spring Hill districts, New Mexico, and on the Rio Francisco, in Arizona.

Copper impregnations were noted in the orthoclase-porphyrite on Mount Turnbull, and along the northern bank of the Colorado between the "Rio Virgen" and Boulder Cañon.

The Santa Rita mine produces native copper, but as a rule the deposits of the southwest, so far as developed, are oxidized ores, often in large bodies, extremely rich. While this condition is not favorable to permanency, yet this is compensated for by the great field for prospecting the increasing number of producing localities.

The total copper production for the United States in 1882 was 90,646,232 pounds, of which 31,288,767 pounds, or about one-third, came from Arizona, Montana, New Mexico, California, Colorado, Utah, Wyoming, Nevada, Idaho, while in 1885, of a total production of 170,962,607 pounds, more than one-half, or 97,461,849 pounds (*i. e.*, 15,000,000 pounds more than the product of the Lake Superior region), came from the same territory, Montana alone having produced 67,797,864 pounds, or nearly as much as the whole Lake Superior region. (See Mining Statistics, 1885, p. 210.)

The ores of Arizona are principally carbonates and oxides, the principal centers being the Clifton, Bisbee, and Globe districts. Coal, mostly bituminous, and principally in the Tertiary and Cretaceous formations (with beds also in the Carboniferous), is found distributed far and wide. It is believed that one bed extends from the western border of the Plateau near Cedar City and Kanara, in Utah, southeastwardly to the Rio Grande, over 500 miles. This is found in the Tertiary and Upper Cretaceous, as is true generally for the coals of the Great Colorado Plateau system. Lignites have an exposure among other localities in the Cretaceous rocks throughout Colorado and New Mexico, and on Oak Creek south of the Arkansas. Coking coals of the Cretaceous were noted at and about Trinidad and near Hamilton, Colo.; also on Twin Creek, Wyoming. Few coals were discovered in Arizona, but evidence of extensive beds in Colorado and New Mexico is most abundant. Thin beds of anthracite (altered by volcanic dikes) were noted at Los Cerillos and the Placer Mountains, New Mexico, and Ohio Creek, Colorado, and semi-anthracites in the Placer Mountains near Silver City, N. Mex. Between Trinidad, Colo., and Las Vegas, N. Mex., Professor Stevenson determined the geological horizon of twenty-six distinct superposed beds, of which his is the first systematic examination. Bituminous coal is found at Golden, Boulder, Cañon City, Colorado Springs, the San Juan region in Colorado; on Red Creek near Elizabethtown; Nacimiento east of Mount Taylor; San Antonio; 8 miles north of Fort Wingate, and near Acoma, in New Mexico; 16 miles north of Fort Apache, and 12 miles west of Fort Wingate, and 25 miles northwest of the Moquis villages, in Arizona; and in Castle valley, the Muddy, San Rafael, and Sam Pitch valleys east of Kanara, and North Fork of Virgin, in Utah; at the source of Twin Creek and Ham's Fork of the Bear and Green River basins, in Wyoming, and elsewhere too numerous to mention, as will be seen from the many reports. The principal anthracite coal of Colorado is found on Slate, Anthracite, and Ohio creeks, of the Gunnison drainage. (See p. 32, Mining Statistics, 1883–'84.) There are stores of coal underlying tens upon tens of thousand square miles of area surveyed, yet only scarcely scratched, and but most superficially known.

PRODUCTION OF IRON AND STEEL IN 1882.

[Taken from mining statistics.]

Locality.	Pig iron.	Rolled iron.	Iron rails.	Steel rails.	Steel ingots.
	Tons.	Tons.	Tons.	Tons.	Tons.
Colorado	23,718	4,739	....	18,217	23,512
California	867	25,843	2,096	5,164	....
Oregon	6,750	....	....	....	....
Utah	57	....	....	....	....
Total	31,392	30,582	2,096	23,381	23,512

The foregoing serves to give an idea of present rate of iron and steel production, which is not at all commensurate with the extensive sources of supply, most of which are not yet fairly explored, even, in vast regions mostly too remote from large manufacturing centers and other consumers of iron products. The principal sources of iron production in Colorado are the South Arkansas, Hot Springs, Placer, Silver Cliff, and Grape Creek districts; in California, at Clipper Gap, Placer County; and in Utah, at Iron County. The latter mines (magnetite and hematite) are found 8 miles west of Cedar City, covering a known area of 2½ to 5 miles, where principally assessment work only, to hold the claims, has been done

Hematitic and magnetic iron ores were noted by Professor Stevenson in Archæan rocks in the Placer Mountains, and carbonate ores in Cretaceous shales of the Arkansas and Galisteo regions. Good ore is plentiful in many parts of New Mexico, in the Raton, Sandia, and Santa Fe Ranges, on the Rio Puerco, and elsewhere.

Chromic iron in considerable quantities is found in San Luis Obispo County, California.

Iron croppings (magnetite and hematite) were discovered in a wash on the northern bank of the Colorado between mouth of Virgin River and head of Boulder Cañon. (For other localities known and discovered, see various survey reports.)

Zinc is found principally as zinc blende, and also in silver ores, within the survey region, and especially in Gilpin County; on Leavenworth Mountain, near Georgetown, in galena ores in small quantity; on Brown Mountain in larger quantity and more refractory; also on Republican Mountain in more than usual amount.

It occurs to some extent in the Leadville ores and in the Ten-Mile district, and in the Little Giant mine of the San Juan region. Arsenides of nickel found in Churchill County, Nevada, are rich, but not largely developed. (See Blake, Mining Statistics, 1883-'84, p. 537.)

The only tin ores opened within the region of survey were the Temescal mines, California, situated on the southwest slope of the Temescal Mountains. The vein extends a considerable distance, and is reported to contain 18 per cent. of tin. Tin was discovered in 1883 near San Diego, Cal., Fort McKavett, Texas, and in the Black Hills of Dakota, and is known to exist in the granite regions of Idaho and Montana.

Salt deposits were noted at the Great* and Little Salt Lakes, Utah; also in Sam Pitch, Juab, Millard, and Sevier Counties; in Snake Valley, Nevada, near Salina; and on the Virgin River, Utah; in South Park; on Salt Creek, Colorado; in New Mexico, 7 miles east of Zandia Mountains; Ojo de Tao, a salt marsh 70 miles south of Galisteo; and Lake, 40 miles south of Zuñi; also in the saliferous sandstones between the Colorado Chiquito and Moquis village at Sunset Crossing; Santa Catalina; and Croton Springs, Arizona. Salt in lesser quantities has also been noted at very many localities.

An alum cave was discovered near Cook's Peak, New Mexico. Alum is also found in Jefferson County, California; near Auburn, Placer County, California; in an alum-bearing bed on the Gila, in Socorro County, New Mexico; on the Verde River in Arizona, and in many places in Utah.

Analyses of the Owens, Mono, and Black Lakes, California and Nevada, develop the presence of immense quantities of carbonate of soda. Extensive beds of borates of lime have been discovered near Death Valley, Inyo County; at Desert Springs, Kern County, and in the Calico district of San Bernardino County, California, independent of those already known in the central part of Nevada.

Nitrates are found in the Cosñino caves, Arizona. Garnets and aqua marines, with occasional small rubies, were noted northeastwardly from Old

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* It is estimated that the annual output of salt from Great Salt Lake is 100,000 tons (1887).

Fort Defiance; turquoise, in thin, irregular seams, at the old Spanish mine at Los Cerillos, N. Mex., and milk opal, inclosing fragments of basalt, on the Gila River, above the confluence of the San Francisco.

Sulphate of antimony and arsenic were noted in silver ores in the San Emigdio and Banner districts, California, and in Green Mountain, 15 miles south of Kernville. Antimony is produced considerably from mines on Coyote Creek, Iron County, Utah.

Petroleum is found in many parts of Colorado, especially in Fremont County. It was first bored for on Oil Creek northeast of Cañon City, a later notable well being 11 miles southwest of Cañon City, in the Arkansas Valley, which region affords abundant opportunity for prospecting. Petroleum exists also in many counties of California. Among those known are Humboldt, Los Angeles, Ventura, Santa Clara, San Mateo, Santa Barbara, San Luis Obispo, and Kern Counties. Details of their development and product will be found in several survey reports and in mining statistics.

Asphaltum occurs at Rancho la Brea, 7 miles west of Los Angeles, in commercial quantities, and over a large area; also in Santa Barbara County, and on Sulphur Mountain.

California consumed and produced in 1884 about 2,500 tons of asphaltum, exporting only to British America, Oregon, and Nevada. Sulphur occurs in Southeastern Idaho, near Swan Lake, and near Soda Springs, Oneida County; in several localities in New Mexico; in Santa Barbara and Ventura Counties of California, and near Humboldt House, Nevada; and at Cove Creek Fort, Millard County, Utah, within region of survey, but the output is inappreciable from any of these localities, due to the cheap price of Sicilian sulphur and cost of transportation. The yield (a decreasing one) in 1884 was about 500 tons for the whole United States, coming principally from the Nevada mines. In 1885 the yield from the Utah deposits had increased.

Many other economic minerals were noted, nearly all of which were in an undeveloped state, and when one reflects upon the profusion and range (from the latest Quaternary to the Archean) of the geological formations exposed within the territory in question there need be no surprise in the future at any actual mineral discovery. The search has begun in earnest, the chances for fraud are gradually becoming lessened, business principles are applicable in more cases than hitherto, and it may be said that the mining industry, as a whole, of the Western mountain region is only in its infancy, but certain of a sure and healthy growth.

The foregoing references, gathered somewhat at random, serve to give a hasty view of mining outputs and the existence of ores, while the possibilities, now but comparatively little known, are vast and widespread, awaiting both exploration and development.

A tabulation following, census data, indicates the increase in manufactures for the survey area for 10 years, and the actual annual production at each decade.

TABLE SHOWING MANUFACTURES FOR AREA SURVEYED WEST OF THE 100TH MERIDIAN (NINTH AND TENTH CENSUSES).

States and Territories.	1870.			1880.		
	Establishments.	Capital.	Products.	Establishments.	Capital.	Products.
	Number.	*Dollars.*	*Dollars.*	*Number.*	*Dollars.*	*Dollars.*
Arizona	15	186,500	142,174	47	177,775	374,496
California	540	2,983,600	5,026,871	1,861	2,336,[illegible]	4,954,358
Colorado	256	2,835,605	2,852,820	861	4,300,714	*14,237,700
Idaho	3	12,500	13,330	39	105,950	300,959
Nevada	306	4,954,770	15,273,606	168	1,106,060	1,930,455
New Mexico	160	1,376,500	1,330,400	196	449,625	1,250,932
Oregon	46	104,550	120,714	104	212,600	961,881
Utah	505	1,298,736	2,112,617	625	2,612,507	4,279,944
Total	1,830	13,541,616	26,876,041	3,901	11,482,910	28,966,774

* This includes all of Arapahoe County, comprising Denver alone, which had (1880) 289 establishments, $3,301,[illegible] capital, with $9,367,749 as a product.

The total shows not alone the comparatively small amount of manufacturing to the grand total of this industry, but its insignificance as compared with agriculture even, the latter being less than one-third of the production of the precious metals for the same area.

The exterior commerce of the area surveyed may be said to consist, principally, in the importation of produce and manufactured goods, mining machinery, implements, fluxes, &c., and the exportation of ores, bullion, cattle, horses, and wool.

The local commerce consists more especially of the delivery, of things imported from entrepots, to the consumer, and the concentration, of things exported at entrepots, and their invoice and shipment to the distant market.

A commerce transiting the area is a part of the present function of the Pacific railroads. In means of communication the region in question, since it came within the ken of civilization, has advanced from a condition of comparative solitude, where lines of aboriginal travel followed the rude, natural tracks of the nomadic tribes, through the era of military and common roads, national, state, municipal, and corporate; then that of railroads, subsidized and non-subsidized by the State; of water-ways, natural and improved, and bridges following the call of an increasing population and industry.

Relatively the water-ways are but a small factor in the element of communication as a whole. Railroads have already and will in an increasing ratio assist industry in the development of surface and hidden value.

These will consist of the great trunk lines forming parts of the systems from ocean to ocean, and of north and south meridional or arterial lines, flanked by side lines, reaching, finally, the most remote and inaccessible of mountain fastnesses, wherever the storage of sufficient actual or presumptive wealth is revealed.

These main lines are to become factors in the great globe circuits of transit and, to meet the want of a civilization ever hungering after fresh fields to conquer, must be adjusted to the most natural road-beds, following the most direct lines, with the easiest gradients, with absolutely permanent beds, and wide tracks, while mechanical ingenuity must be taxed to produce heavy engines with driving machinery (electric) capable of, say, 150 miles per hour. The distance from New York to San Francisco could then be made in about 24 to 30 hours' actual running time.

IRRIGATION.

Most of the agricultural lands within the region of survey require irrigation in order to be productive, either on account of an insufficient rainfall, or, if sufficient, its irregular distribution throughout the year. For minor localities, irregularly distributed, and for certain seasons, crops will mature without irrigation.

Irrigation being, therefore, the rule, the conditions which it imposes become of primal importance, and these relate particularly to the water supply and its utilization.

The greater share of the land rated as agricultural is both chemically and mechanically fit to respond to the husbandman, sufficient moisture being, naturally or artificially, supplied. The surface forms often forbid its practical utilization, no matter how much water may be available, because of steep slopes and inaccessibility. However, as a rule, as much land may be reclaimed as there is water available, and in most instances more.

These lands are in the most level parts of the valleys and plains.

The conditions surrounding the lands adjoining the flanks of the Sierra Nevada and Rocky Mountains have been compared with the broad valleys and plains of the Indian peninsula through which flow streams with far distant sources in the Himalaya. The general or main conditions as to water supply in the two cases are unlike, at least for three reasons:

(1) While the acreage is large in the United States it is relatively much smaller than that in India, especially on account of the usually narrow valleys and spaces occupied by subordinate mountain forms.

(2) The annual precipitation for the western region is less, usually, both for valley and plain and mountain proper

(3) The region of perpetual snow, of itself an immense natural reservoir, self-feeding at a time of minimum supply, for the western mountain interior of the United States is relatively insignificant as compared with that of the Himalaya. In fact, water is in deficit in the western interior; hence its future actual and relative values admit of great possibilities. Outside of the few streams gauged by this survey but little critical data as to the water supply exist, beyond meteorological observations, supplemented by general examinations.

While no exact statement can be made as to the relation of the minimum supply of water to the actual amount of land to be irrigated, enough is known to render the caution proper of advising the measuring of the supply as the first preliminary, no matter how inviting may be the presence of wide expanse of ground only needing the application of water for its

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*Moncrief, in his "Irrigation in Southern Europe," says: "It is usual in India that the irrigable area far exceeds the water at command with which to irrigate." (Introduction, p. vii.)

fructification. It cannot be doubted that many lands redeemed by irrigation will yield, perennially, bountiful crops, on account of the spread of fertilization through silts carried to them by waters, as is evidenced on a large scale and for long periods in the valley of the Nile (both theoretically and practically), and in a lesser way for the valley of the Rio Grande in the United States.

The pre-requisite information upon which to base a judgment as to the true and complete function of irrigation as a factor in production can only be determined by special detailed instrumental surveys of the topographic features of the areas involved, especially of their hypsometric relations, for the preliminary lines of canals and other engineering structures, and, above all, for the measure of the water actually available, and especially at its lowest stage during the crop season.

The needs for and advantages of irrigation are both self-evident, and while the advantage of developing systems of irrigation on a large scale by the General Government* during the early stages of settlement of the West, and especially when the remuneration to private capital to engage in them is not sufficient to justify its employment, is manifest, still such direct relation between the General Government and a fixed industry of the land is not warranted, constitutionally or by precedent, and would entail added duties likely to reach over large proportions.

However, when waters for irrigation shall be required from navigable streams, the jurisdiction over which rests with the General Government, it will be necessary to ultimately fix by law the regulation of the diversion, distribution, and use of water so required, so that commercial and other interests shall not suffer unduly, if at all.

The systems of irrigation principally employed in Southern Europe and India have been by canals and reservoirs or tanks.† The former is by far the most efficacious and extensive, the latter being either primitive or confined to small areas, except, possibly, the large reservoirs for storing irrigation water in Alicante.*

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* In 1872 it was estimated (see p. 31, Prog. Report, 1872) that the United States then possessed about 200,000,000 acres that might be reclaimed by irrigation, but since then the greater share of this ground has been appropriated under the various land laws. (See Appendix, Survey and Disposal of Public Domain.)

† Reservoirs and tanks must of necessity be above the practical heads of navigation of streams, and where simple and economic in construction, be confined to comparatively small catchment areas for their supply. When arterial and local canal conduits are established, a system of tank-supply is destined to develop in connection therewith and as subordinate thereto, economizing much of the water that would otherwise run to waste. Where employed in India in case of irrigation-works fed

Tanks or reservoirs as storages of surplus become adjuncts to complete systems, looking to the utilization of the larger portions of the supply in regions where freshets prevail or the rains all fall in a brief interval. In India, where the most extensive undertakings have been developed, the system based on the simple principle of gravity has been designated by the Royal Military Engineers as "canal," "natural flow," and "surface irrigation."

This system is adapted to large areas in the United States.

For economic and sanitary reasons a scheme of drainage to relieve all surplus waters and return as much as possible to the normal channel is requisite.

Practice seems to indicate that the combination of irrigation and navigation is not, as a rule, advisable, and that the distribution of water should be by measurement.

The modulus, or amount of water required for irrigating a given quantity of land, varies according to amount and frequency of rain during the season of cultivation, the kind of crop, and somewhat upon the porosity of the soil.

A modulus of 1 cubic foot per second for 83.4 acres, watered during six months of irrigation, is given for the South of France, being a mean of 28 acres for gardens, 50 for beans, 70 for meadows and lucerne, 168 for madder, 184 for chardon, and 454 for sundry other crops, watered only in

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by rivers having mountain sources, they have maintained an all-year-round supply that otherwise would have been limited to the interval from June to December, whereas in cases of rivers with *large* catchment areas not rising in the mountains, with adjunctive tanks, the supply was variable and uncertain, and much more so for *small* catchment areas. Tanks were extensively used on a considerable scale by the natives in India prior to British occupation. Not being prime factors in a competent and thorough engineering scheme for irrigation, their actual or prospective use should be recommended with great caution, and determined only after instrumental test and mathematical verification, resulting, necessarily, from ample examination and special survey.

*See Irrigation in Southern Europe, Lieutenant Moncrief, Royal Engineers, 1 vol., 8°, 371 p., London, 1868. Italian Irrigation, by R. Baird Smith, captain of Royal Engineers, 2 vols., 8°, pp. 434 and 380. Irrigation in Southern India, by R. Baird Smith, Royal Engineers, 1 vol., 8°, pp. 148, with plates, London, 1856. Report of Irrigation Commission for California Valleys, being H. Ex. Doc. No. 290, Forty-third Congress, first session, pp. 91, with maps; and Practice of Irrigation in India, Egypt, Italy, &c., being S. Ex. Doc. No. 94, Forty-fourth Congress, first session.

an emergency. The large unclassified areas render the result of little value.

In Northern India, in case of the Eastern Jumna Canal, where about 20 per cent. is lost by filtration, evaporation, &c., over a distance not less than 300 miles, it is found that 1 cubic foot per second suffices for 250 acres, the crops in question being 18 per cent. each for rice and sugar-cane, 50 per cent. of wheat and barley, the former watered from 10 to 12, the latter 4 to 6 times, and the balance of inferior crops watered only once or twice. Here the rainfall, coming principally in June, July, and August, is about 40 inches, and the evaporation is greater than that at Madrid, given at 65 inches.

In the Henares Canal, in Spain, 1 cubic foot per second is found to irrigate 140 acres, and in Lorca, in the province of Murcia, 210 acres are irrigated per cubic foot. In case of the great valleys of California, the irrigation commissioners were of the opinion that a reasonable allowance for the land commanded by the proposed canals would be 1 cubic foot a second for each 200 acres, and they conclude that it would cost about $10 per acre to irrigate these valleys. Here the evaporation is high, and quite equal to, if not greater, than that at Madrid.

While this will answer well enough for sections in vicinity of the 40th parallel, and areas to the northward and to the south, even perhaps to 35° N. latitude, yet the area irrigated is quite too large for tracts bordering on the Mexican line. Nothing less than actual experience will warrant a determinate modulus, on account of the varying conditions.

Irrigation by canals is now carried on in a comparatively small way, and without special system, in the interior of parts of California, Utah, New Mexico, and Colorado.

The many difficulties besetting a generalized system, resulting largely from vested water rights, may yet be overcome as land advances in value and combinations of owners call on the State for either supervision or aid.

The State engineering department of California has among its duties to investigate the problems of irrigation of the plains or valleys of the State.

Co-existent with irrigation should be the reclamation of swamp, marsh, or overflowed lands, lagoons, and flood plains, by arterial systems of drainage.

The irrigation commissioners in their report very properly advise the permanent adherence of the water to the land in the following words: "As a matter of public policy it is desirable that the land and water should be joined together, never to be cut asunder; that the farmers should enjoy in perpetuity the use of the water necessary for the irrigation of their respective lands; that when the land is sold the right to water shall also be sold with it, and that neither should be sold separately."

At present vested rights have intervened largely, pursuant to the act of July 26, 1866, which provides "that whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and decisions of the courts, the possessors and owners of such vested rights shall be maintained and protected in the same, and the right of way for the construction of ditches and canals for the purposes aforesaid is hereby acknowledged and confirmed."

A judicial interpretation thereon appears in the following extract from the decision of the Supreme Court (see p. 75 A. R., 1876): "4. In the Pacific States and Territories a right to running waters on the public lands of the United States, for purposes of irrigation, may be acquired by prior occupation, as against parties not having the title of the Government."

The supreme court of the State of California has confirmed (Heydenfelt, 5 Cal., 397, 1855) substantially the occupant by possession as against the parties subsequently appropriating the waters under like conditions, and declares the doctrine which must determine in other cases of occupancy after perfection of title, a more thorough and complete recognition of the rights to a specified amount of water, because of prior appropriation, which amount can be limited by nothing short of the entire volume of discharge.*

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*It is understood that later California decisions substantially require the return of the water unharmed to its natural channel at a lower level (1887).

A rainfall of from 12 to 14 inches, properly distributed, would produce cereal crops without irrigation, while in case of a much greater precipitation recurring irregularly it would be requisite. As a rule irrigation implies that the increased production results from a lesser area than that whereupon the necessary amount of rain utilized actually falls.* Moncrief gives examples of irrigation being used where there are 40 inches of rainfall.†

Whatever the conditions of rainfall, the more or less ample result from the use of all natural flowing waters is, after the most complete system of canals shall have been made for diverting it to this use, governed to a large extent by evaporation, infiltration, &c.‡ Specially interesting are the relations between normal water supply and its evaporation in inclosed basins, of which Great Salt Lake is a type.

Information of interest results from the topographic and hydrographic survey of the Great Salt Lake and the basin, drained by it, which had for its object, in addition to an accurate detailed survey of the region, a meander of its shores and those of its islands, with soundings necessary for the determination of its present volume; observations upon the evaporation of its surface, with periodic rise and fall; the measurement at different seasons of the inflow and rainfall, with other meteorological observations at selected stations upon its affluents.

The topographic and hydrographic survey was completed (except certain projected lines of sounding and continuous evaporation) reduced and held in original plotting-sheet form.

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*Therefore for each acre irrigated, as is necessary, to the extent that the rainfall is in deficit, robs more than an acre of a greater amount of water on account of loss in transit. It is clear that the drier regions can not afford this demand. However, the rainfall in excess of 20 inches from mountain areas should finally be held for use over a small percentage of the lower levels. Insignificant percentages of the very arid tracts in the western mountain interior will be reclaimed by irrigation. That these tracts are relatively small is an incentive for their amelioration in such a settlement of these regions as can permanently be made in the face of physical obstacles.

†Prof. James P. Espy, in his Fourth Meteorological Report (S. Ex. Doc. No. 65, 34th Cong., 3d Sess.), states that any cause, natural or artificial, producing an upward current of air will develop rain when the complement of the dew-point (the difference between the highest temperature at which vapor will condense and the temperature of the air) is small, the air calm below and above, and the upper atmosphere at its normal temperature. He suggests that masses of timber along a line 600 or 700 miles at the west be fired, with the probability that rain would develop and travel eastward a long distance. This does not appear to be the result of the extensive accidental forest fires of the western mountains, except for localities near the burning space. It is suggested that the Weather Bureau should obtain, through observations from balloons, relative and actual amounts of moisture at stated intervals above sea level, and that experiments be made as to the methods and effects of producing local condensation, artificially.

‡Observations show that ⅓ of the water falling in the Seine is taken by the river to the sea, the balance passing off by evaporation and percolation.

Certain meteorological data are still wanting, such as the measure for a long interval of the atmospheric conditions at the lake surface, the rise and fall of the latter, with annual evaporation, the re-precipitation and the amounts of water actually used in irrigation. Maury estimates the mean annual rainfall for the whole earth at 60 inches and principally in the torrid zone, with a mean of 37 inches for the north and 26 inches for the south temperate zone. Maxima are found at the rate of 86[*] feet per year in the Andes, between 30° and 40° south latitude, and in mountainous India, at the rate of 114 feet per year. The flowing waters of rivers and all other streams represent substantially the amount by which the precipitation (rain, hail, snow, and dew) exceeds the evaporation of the basin, less a small amount permanently transferred below the surface. only a part of which returns to its ocean source.[†]

Evidently the secular variation for the Great Salt Lake, a type of the whole Great Interior Basin, is in the direction of carrying off by the prevailing winds more moisture than is brought to it, a movement which, still continuing, has been going on in varying gradation from the epoch when the ancient "Lake Bonneville" was a member of a fresh-water system of lakes, covering a large portion of the Great Basin.

This is a direct reasonable result from the continental growth that has upheaved across the prevailing humid-laden westerly winds from the Pacific mountain ranges (of which the Sierra Nevada is the greatest and principal barrier), which impinge at a considerable angle to their axis, thereby robbing the moisture-laden air of much vapor, forcing the balance to the upper-air currents, through long distances, only to be precipitated upon meeting counter-currents, or carried with the bulk of the moisture of the upper air from ocean to ocean.

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[*] See Maury: Physical Geography of the Sea, p. 121.

[†] The average rainfall upon any given area depends upon a great variety of conditions, as latitude, proximity to the sea, elevation, topography, extent and direction of adjacent mountain ranges, exposure to the prevailing winds, and generally to the different local causes that influence climate. Whatever acts to lower the temperature of the air, at a given locality, below the dew point, causes rain. The topography is the largest local factor in precipitation.

The total amount of humidity brought to any given area depends upon the amount of evaporation engendered by the heat of the sun in the ocean equatorial belt, and the direction and force of the winds translating this vapor of water to lands of the continent, unequally distributed as they are when compared with water areas, and presenting irregularly disposed masses as they do to the path of these winds.*

Prior to the elevation of the Sierra Nevada to its present level, it is clear that the prevailing winds brought to these regions more moisture than in their onward flight was carried away. The moisture brought to the land by the southeast monsoons of the Gulf of Mexico are without effect in determining the water supply of the Great Salt Lake Basin.

The causes which have led to the present water level of Great Salt Lake are remote or secular, being due primarily to the resultant of the sun's heat, which, bearing upon the ocean, produces the normal supply of moisture, modified by the relations of water to land surface, the levels of continental forms, the irregular motion of the earth about its axis, if not to other relations not yet analyzed. The former produces the air currents, governed by varying conditions not now fully understood, while the later continent-building fixes limits to local precipitation, and gravity, unimpeded, dictates the return to the sea of the waters temporarily gathered by the land.

Man's occupation and cultivation serve to equalize somewhat the local relations of precipitation, evaporation, and temperature, but simply as a slight perturbation of the fixed law of secular variation.

Were it possible to determine a mean secular variation in rainfall for this basin, it would apparently be in the direction of dessiccation from the causes outlined.†

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*The amount of rain is increased or diminished according as the prevailing winds come laden with moisture directly from the ocean, or have traversed previously large tracts, particularly mountainous regions, and are therefore dry.

†Geological evidence is in favor of a diminution of the earth's mean temperature during the successive geologic ages. This is presumed to be due to a diminution of the mean solar heat, and to orographic changes and disturbances that have tended to increase the area of the land, as compared with that of the water, and to enlarge the volume above sea level since archæan times. The increase of land surface and general diminution of temperature both tend to dessication. The Great Basin has undoubtedly undergone climatic changes from both causes. The interior of continents everywhere enjoy a less rainfall than areas nearest the ocean shores. This is specially marked in the Great Basin, as compared with the western slopes of the coast ranges, and the Sierra Nevada at all latitudes. The latter, for instance, robs the Inyo range, although only about 20 miles to the eastward, parallel, and

Long continued observations will establish cycles of maxima and minima (within which annual and minor fluctuations occur), means of which will finally give the more permanent, secular, or climatic movement, independent of the physical relations surrounding the maxima and minima of precipitation, temperature, evaporation, relative humidity, etc., which determine the amount of moisture brought in the atmosphere over these regions. There are others which by contrast may be termed local, which refer to changes in the level of the lake, and in the amount of inflow, by human agency, in irrigation, and the changes due to man's occupation.

There seems to be no question as to the actual temporary increase of the streams in this basin since it has been settled.

This appears from relative measurements, and the increase of the water surface, if not in its volume.

Mr. Gilbert states (p. 66, Arid Lands), an area of 1,750 square miles for the lake surface in 1850 (Stansbury) at lowest stage; 2,166 square miles in 1869 (King) near its highest stage; while in 1878 the area of the water surface (including that of the island) was found to be 2,263 square miles, at a time when the streams had begun to rise and the springs were well supplied from the spring rains and melting snows. The mean depth in 1878 was found to be 15 feet, while none is given for 1850 and 1869; an estimated variation

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nearly as high, of most of the moisture that should otherwise reach it. (See "The climatic changes of later geologic times, J. D. Whitney: Memoirs of the Museum of Comparative Zoology, Harvard College, Vol. VII, No. 2, 1882.) The geologic observations of Messrs. King, Gilbert, and Russell, point to two humid maxima, separated by an interval of aridity, together with an arid epoch, before the first or most pronounced humid maxima, and also the present period of desication, all as having occurred during the Quaternary. The humid epochs are stated as coincident with a larger and a lesser glacial period. The observed data upon which this depends is founded, alone, upon two alluvial gravel between two lacustrine clay or marl beds (see Second A. R. U. S. Geol. Surv., p. 169, and Monograph XI, Russell; Geological History of Lake La Hontan). The connection is not clear. It has been estimated that the so-called last glacial epoch terminated about 80,000 years ago. Various theories refer to glacial phenomena as general in character, whereas Frankland refers their sole cause to a higher ocean temperature than the present, thus defining glaciation as local. As historic records do not afford evidence of any great secular climatic change, say within 2,000 years or more, it is safe to assume that the period at which the Great Basin Lakes were at their maximum, was many thousand years ago, since which a secular change in climate has occurred from a state of considerable humidity to that belonging to the present desication. The weather elements have only been measured instrumentally about 100 years (thermometric records began, Paris, 1763, Stockholm, 1758, London, 1775), hence nothing can be predicated upon them as to the present movement of the climatic curve. Schott finds (see Smithsonian contributions, Tables, Distribution, and Variations of the Atmospheric Temperature, by C. A. Schott, 1876, p. 311) nothing to indicate a permanent change in climate in the records for ninety years. For long periods to come we must be content in gathering and comparing the maxima and minima of precipitation, temperature, relative humidity, and direction of the winds, without being able to plot the secular curve and assign the actual climate of to-day to its proper place thereon.

of 20 inches for the mean normal variation in level is given. Independent of the oscillation due to the ratio between evaporation and inflow, there is a change which appears to be regulated at present by an increase in the tributary streams. This increase gives a rise of 7 to 8 feet, and one-sixth larger area.* This latter change has been explained theoretically by volcanic, climatic, and human agencies

The two latter are unquestionably involved as factors, while no evidence exists as to the former producing a change in the level of the bed of the lake, and it is apparently refuted by the fact that the water has risen alike against all the shores and islands so far as known.

If upheaval determined the enlargement it would scarcely account for its maintenance, as the evaporation is, approximately, 7 feet annually.

The most probable explanation of the change now going on in the water supply of the lake is that of slow climatic oscillation, modified by man's agency, especially in cultivation.

Observations extending over long intervals will alone give the data by which the local or temporary fluctuations can be segregated and the secular movement be made clear.

From the climatic cause it is not reasonable to expect a long continuance of greater water supply, but on the contrary, a minimum having been reached, the next minimum bids fair to be less than the one next preceding, while human agencies are in favor of increasing the amount of rain within the basin on account of increased evaporation, and hence re-precipitation, and an increase due to the local cumulation of moisture to the degree of saturation necessary.

The human agencies are cultivation, raising of herds, and cutting timber. Irrigation has diminished the inflow to the lake, but increased the active area of evaporation.

Drainage and cutting out beaver dams have increased the inflow, but tend to decrease the land evaporation.† The inflow of the lake is increased by grazing and timber-cutting, while the land evaporation has been decreased. Human agencies have no permanent influence on the total rainfall within a given basin, but cultivation tends to equalize it, and is in favor of a slight temporary increase through re-precipitation.* This leaves 16,000 square miles in which it would appear that the average should be as large, if not larger, than at Salt Lake City. This is about thirty-five times the volume that reaches the lake, according to Lieutenant Young's measurement and estimate of 6,000 cubic feet per second inflow.†

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* Mr. Marcus E. Jones, of Salt Lake, gives a maximum rise of the lake from 1860 to 1872 of 13' 4", and a rise from 1849 to 1854, of 4'; and a fall from July, 1854, to January, 1860, of 4', and a still further fall from July, 1872, to January, 1884, of 9'.

† Evaporation is influenced by extent of surface, temperature of air, dryness, stillness, and density of the water.

The cubic feet of water delivered in one year at above rate would be 18,921,600,000, while that from a rainfall of 17.22 inches over 16,000 square miles would be 642,318,336,000 cubic feet, or a presumable amount not reaching the lake of 623,396,736,000 cubic feet, sufficient to raise the lake nearly 10 feet.

The far greater area of land, when compared with that of the lake, which absorbs and evaporates both, accounts, doubtless, for the above relation in the main; at the same time it is reasonable to conclude that considerable portions of the vapor rising from this rapidly-evaporating surface are translated outside of the basin before the temperature of proper condensation is reached.‡ The perimeter of the Great Salt Lake in 1878 was found to be about 380 miles, with an area of 2,363, from which, subtracting 100 square miles for the islands, leaves a water surface of 2,263 square miles.

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* The average rainfall (compiled by the Signal Office from the post hospital reports) at Fort Douglas, Utah, from January, 1871, to July, 1883, was 17.53 inches. The average for eleven years (1875 to 1885, inclusive) at the signal station at Salt Lake City was 17.22 inches, with a maximum in 1875 of 23.64 inches, and a minimum in 1880 of 10.94 inches, corresponding to a minimum temperature of 46° F., while the next less mean rainfall, 13.11 inches, in 1879, corresponds to 53° F., the maximum mean annual temperature. On p. 228, Tables and Results of Precipitation, Smithsonian Contributions, Mr. Schott remarks upon a type curve as pointing "to a gradual increase of the average annual precipitation from about 1818 to the present time" for the east coast from Maine to Virginia, but finds the variation in the Ohio Valley, and as far west as Missouri, to be different, though not opposite, and makes no comparisons for the regions farther west. Mr. Gilbert estimates 12,500 square miles as bringing no water to the lake.

† The volume of supply equals the rainfall plus incoming streams and a few springs. The annual evaporation is shown by the "supply," plus the fall or minus the rise.

‡ The results of observation on the relative evaporating action of earth and water are conflicting. Observations at Geneva for a year showed $199\frac{1}{12}$ lines from earth, and $536\frac{1}{12}$ lines from water; others at the Helder, in 1869, gave water 609.9 millimeters, and 1,399.6 millimeters for ground covered with clover and other grasses. The evaporation from the Nile is stated to be three times greater than from the ground bordering it (see Marsh., p. 441). The conditions of the Nile Valley in Egypt and Nubia are more like those of Salt Lake than are those at Geneva and in Holland.

The approximate mean depth is 15 feet, with a greatest measured depth of 39 feet. The mean or average volume was (1878) 946,347,288,000 cubic feet, equal to an inflow of about five years at 6,000 cubic feet per second, undisturbed by the relations between precipitation and evaporation.

Lieutenant Young found the fall of the lake to be 31 inches from March, 1878, to March, 1879; assumes a rainfall for the whole lake of 12 inches for same interval, and 40 inches rise for an inflow of 6,000 cubic feet per second (measured and estimated), which factors aggregate a probable total annual evaporation of 83 inches. (See p. 230, Annual Report, 1878.)

A simple mean of bi-daily observations at level of water of lake near Farmington for eleven days in July, six in August, and three in September, 1879, gave a mean daily evaporation of 0.52 inches.

Mr. Gilbert refers to a total annual evaporation of 80 inches (See p. 73, Arid Lands). Through courtesy of Mr. Gilbert I have been furnished observations taken by Lawrence Burgess & Co., at their salt works near Salt Lake City, showing an evaporation of 12¼ inches for the first twenty-six days of August, 1877, or a daily average of 0.47 inches.*

The time was, and the remaining beach terraces of Lake Bonneville are a silent witness, when more moisture was brought to this water-shed than escaped from it, and the excess of precipitation over evaporation created a level which permitted the ancient drainage to the Columbia; whereas it appears evident that these same agents now, throughout the whole great interior basin, have carried off more moisture than they have supplied, leaving the many reservoir lakes, saline and alkaline flats as a result. While no measurement at hand gives us the exact ratio of precipitation to evaporation, yet observations already made are sufficient to render tenable the theory that this desiccation is justly due to the secular agency of the winds.

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* King reports an observed evaporation of one-half inch per day in the Great Basin, for the driest period of the year (p. 526, Vol. 1, Systematic Geology).

Lieutenant Bergland estimates from a daily mean of 0.784 for four days in August the annual evaporation at Camp Mohave at 95.77 inches, and gives other yearly evaporations in inches as follows: Cumana, 120; Dead Sea, 96; Marseilles, 73.2; Palermo, 58.4; Manchester, 41.0; London, 28.8; Rotterdam, 23, and Breslau, 14.8—. Moncrieff gives the evaporation for Madrid at 65 inches, which he estimates as considerably greater in Northern India.

The annual evaporation of the Red Sea, at a moderate estimate, is half an inch per day in summer (See Ansted Physical Geog., p. 150).

The annual evaporation from water at the Helder in 1861 was found to be 602.9 millimeters = 23.69 inches, and at Geneva it is stated at 536¼ lines = 63.3 inches.

The evaporation near shore of Kern Lake, August 14 to September 20, 1879, was found to average 0.316 inch daily (see Hall, Physical Data and Statistics of Cal., 1886, p. 377).

The irrigation commissioners assume that the evaporation in the interior valleys in California is high, and quite equal to that at Madrid.

The climate of the globe is one complex whole, where action and reaction sensitively, if not sensibly, permeates throughout its entire atmospheric envelope or covering, and that of any one basin is interdependent on all the others, and in ever-recurring measure upon the winds that circuit all.

At the rate of 1 cubic foot per second for the irrigation of 200 acres, the average discharge of 6,000 cubic feet admits of irrigating 1,200,000 acres by the inflowing of Great Salt Lake. Of this amount 700,000 acres could be irrigated by the Bear River, while the land classification examination shows that the arable space in sheets 41 A and B, embracing only a part of the Bear River drainage, is 663,200 acres.

Likewise, assuming that arable lands are so situated with reference to the Jordan, Weber, and minor streams that they may be reached by gravitation, it is not too much to assume that all of the inflowing waters of the lake may be in time diverted from this reservoir, leaving its bottom a saline flat, or with at best a number of minor or local reservoirs at the deepest points.

Whatever man may do, nature will proceed uninterruptedly in its course; and the secular movement being one of desiccation, a saline bed will ultimately be all that is left of the Great Salt Lake from natural causes.

Meanwhile the temporary outlook is favorable to irrigation, cultivation, and the full utilization of the available water supply to its utmost maximum, with promise of favorable results where judgment is used.

This may be done by a system of canal irrigation, with tanks or artificial reservoirs as a limited adjunctive; planned to utilize, if need be, every cubic foot of water precipitated. While farming without irrigation may doubtless be safely carried on where the downfall exceeds 20 inches, yet for the whole interior basin, and indeed for much of the western mountain region, especially that part south of the fortieth parallel, and particularly not including the more humid Northwest, crops may be at least doubled from its use, and ordinarily the soil be fertilized from the silt deposited. The control of the natural water supply is also a matter of importance to the present extensive mining industry.

ARTESIAN WELLS.

Because of the large areas throughout the western mountain region that may be cultivated by the aid of water artificially conducted to it where the natural supply is below the essential normal, it becomes a matter of prime necessity to utilize to the utmost every known resource; and hence artesian wells are to play, in quite a limited way, an important function among these arid tracts. Artesian water may be said to comprise all that store or reservoir held in permeable ground, between impermeable beds, the distant source of which affords sufficient pressure to force it to or above the surface of a boring or well sunk through the upper impermeable strata.

Water supply thus obtained is called artesian, from the town of Artois, in France, where such sinkings were made in the Middle Ages; but the discovery that water might be so obtained dates back to the older civilization of Egypt; prior to historical times in Asia Minor; and they have been sunk in Persia, China, Algeria, the Sahara, and Lombardy.

The conditions necessary are a continuous pervious stratum of sufficient exposure to collect the supply, inclined so that the water enters higher than the site of the well, with substantially water-tight beds over and under, to prevent escape in a vertical direction, with rainfall adequate to the use for which the supply is intended, and an inappreciable lateral escape from the sides both of the reservoir and the well. The elevation to which water will be forced from an artesian opening will be the height of the supply less the diminished height due to less pressure from loss of supply through rents and fissures, the great amount of friction of the irregular rocky underlying bed, and the resistance of the atmosphere.

It must be remembered that a large natural overflow will lower the general water line to its own level, and that also in a certain class of wells the flow is caused by the expansive force of pent-up gases, disseminated through the water itself, or held in a contiguous communicating reservoir. This is believed to be usually the force in petroleum wells. It is doubtful whether any rock is impenetrable to water under a sufficiently high pressure, but high pressures and great depths (say below one mile) are not, as a rule, compatible.

The porous beds which reservoir the water may be of sand and gravel (drift), alluvium conglomerate, loose chalks, arenaceous strata, and granular magnesian limestones, certain granites and greenstones, the latter through fractures and fissures and some sandstones through pores, coal measures of alternating sandstones and shales, or in general, with notable exceptions, the newer geological formations. The impervious strata consist generally of the Archæan rocks (granites, quartzites, and other crystalline rocks), clays, argillaceous and marly strata, clayey shales, shaley limestones and sandstones, and compact sandstones.

Water is not generally found in Archæn rocks (granites, quartzites, &c.), hence it is not economic to bore in them, and the popular impression that the deeper the sinking the better, is fallacious.*

Mr. Gilbert thinks that the conditions in general for success are favorable in the Tertiaries of the valley of the Sevier of Utah, from Monroe to Gunnison, and to the southward, as well as the line of valleys to the eastward, but not the southeastward, where the Tertiaries are cut by a portion of the cañon system.

Professor Stevenson thinks that artesian water may be had near Galisteo, southeast from Santa Fe, and immediately west of Fort Union, N. Mex., but would probably be unsuccessful on the Canadian plains north from Cimarron Creek.

A geological commission reporting to the Department of Agriculture in 1882 thinks that of all that part of Colorado lying eastward of the mountains, that artesian borings are more likely to be successful in the eastern portion of the area, between the Arkansas and the South Platte, than elsewhere, the porous beds being the Dakota sandstones of the Cretaceous and Triassic sandstones respectively.

I am of the opinion that artesian wells may generally be made successful on the western flanks of the Sierra Nevada, along the eastern side of the Great Interior Valleys, northward from Tehachapai Pass, on the eastern flanks of the Cascade Range, at selected localities from Fort Klamath northward to the Columbia River; also at special points in Atlas Sheets 70 A and C, east of the ranges between the plains and the Rio Grande, in the Cretaceous formations of the flanks of the Zuñi Mountains, New Mexico, eastward from the Sierra Blanca of Arizona, near heads of the Gila River, and in parts of the Tonto Basin. The same is true for many of the inclosed watersheds of the Great Interior Basin, especially in the Bear and Sevier River drainage, as also east of the Humboldt and Pahranagat Ranges, and elsewhere, but intelligent examinations should precede actual attempts at boring. They are not likely to be so, for the Plateau systems of the Colorado River Basin, the permeable beds of which are drained toward the river.

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* Wells have been bored at Saint Louis 3,150 feet, and Columbus, 2,500 feet, without satisfactory result; also at Fort Monroe, 900 feet; Staked Plains, 1,050 feet; Sacramento County, California, 2,160 feet. Hall reports 23 failing cases in California (300 to 2,160 feet); Hon. Horace Beach reports 6 failing cases, Colorado, New Mexico, and Wyoming (200 to 1,500 feet). Artesian water was not found in the chalk at Southampton, England, at 1,317 feet.

Unfortunately the territory where success is most certain is usually now favored with the most rainfall, and hence at present the least in need of this adjunctive water supply. This does not interfere with the great relative value of artesian waters in the more arid sections, and the distribution from more humid to less humid ground by proper storage and conduit conditions.

The State engineer of California reports, in 1886, 646 artesian wells in California, by counties as follows: 12 in San Joaquin (700 to 1,250 feet); 19 in Stanislaus (270 to 1,000 feet); 86 in Merced (130 to 540 feet); 25 in Fresno (150 to 910 feet); 101 in Tulare (200 to 784 feet); 36 in Kern (180 to 850 feet); 119 in Sacramento (60 to 2,160 feet); 408 in San Bernardino (40 to 410 feet); and 40 in Los Angeles (40 to 270 feet).

Professor Chamberlin reports on not less than 15 wells in Wisconsin (300 to 959 feet), and refers to the approximate number of 100 near Denver, Colo. (See p. 150, Fifth Annual Report, Geological Survey).

Various artesian wells are referred to in the Geological Survey Reports of Indiana (Cox) and those of other States.

The well at the Insane Asylum, Saint Louis, at a depth of 3,843 feet, affords a little water, unfit for domestic use. The deepest known well is in Sperenberg, near Berlin, where, in 1871, boring had been carried to a depth of 5,500 feet, the last 3,200 feet through a bed of salt not then pierced.

Artesian wells have been common in China from a very remote antiquity, and some are 3,000 feet deep; that at Nensalzwerk, Silesia, is 2,300 feet.

Other wells are the Dupont well, at Louisville, one at Chicago, and others at Fort Carroll and Charleston.

The French Government has lately bored many wells in Algeria, at depths of from 100 to 200 feet, but they mostly contain mineral matter.

Many artesian wells exist in France, and some in England.

Theoretically the temperature of the earth increases as its interior is penetrated, and actual observations seem to confirm this theory. The average (1 degree for every 50 or 60 feet) usually given is entitled to no great weight, because of the difficulty of obviating the local thermometric oscillations, from the normal rock temperature, before coming in contact with external atmospheric and aqueous heat. This average, assuming the theory of internal fluidity, whether in aggregate or reservoir mass, will depend principally upon the thickness of the crust at the point of observation, its power of conductivity for heat, and in some slight degree by the latitude and altitude of the place. The following temperatures have been noted: Grenelle, near Paris, 82° (1,802 feet); Saint Louis, 73°.4 (3,843 feet); Louisville, 76°.5 (2,086 feet); Charleston, 87° (1,250 feet) (*see* Chamberlin, p. 165, 5 A. R. Geol. Survey); Sperenberg, 114°.7 (3,390 feet); Fort Wayne, 51½° (2,635 feet); Wabash, 50½° F. (2,270 feet); Terre Haute, 81° F. (1,923 feet). Professor Cox cites average increase in artesian wells as follows: Wurtemberg, 1° F. for each 19 feet; in Durham and Manchester, 1° for each 65 to 70 feet; in silver and lead mines of Saxony, 1° for each 65 feet; in Cornwall, 1° for each 75 feet; Grenelle, 1° for each 60 feet; Naples, 1° for each 208 feet, and same city 1° for each 83 feet.

The total precipitation of a district being carried away from it by surface and underground drainage, evaporation, and underground storage, it obtains that by tapping these reservoirs they may be again supplied from the native source through the outcrop of the porous beds, and thus water which would otherwise escape by some of the sources mentioned may be retained and utilized, thus increasing the supply available for irrigation.

Relatively the total amount that may thus be availed of is small, because of the small surface through which its storage takes place, and the larger proportionate share carried off by surface drainage and evaporation.

The State engineer of California reports 1,800 acres irrigated in 1880 in Los Angelos and San Bernardino Counties, California, which has since been doubtless increased, as also areas made available in the great interior valleys of the State.

The artesian reservoirs, removed from the factor of evaporation, store up supplies in case of need, which may be tapped and refilled, the amount drawn off being carried to open-air tanks or reservoirs of suitable capacities.

The porous beds often receive their supply in districts favored with much moisture and carry the same to districts less favored, thus equalizing the humid conditions and ameliorating the more arid tracts.

It is not reasonable to look to them to make productive an absolutely desert area except for very small amounts.

Attention has been invited to this subject more with a view to create an interest in the prosecution of the inquiries preliminary to tests over large areas and actual borings where conditions are favorable.

The examinations made in advance should consist of the determination of the actual topographic and the conjectural geologic profile; the position of outcrop area, lithological character, thickness and extent of the exposed porous collecting beds and their surface conditions; the proper distances of the wells from the same, governed by inclination and comparative elevations of the overlying beds; the quantity and conditions of rainfall, evaporation, &c ; the incoming drainage, if any, from contiguous districts, and disturbances affecting the continuity of the water-bearing strata.

Such data, gathered for large areas by competent observers, would permit of grouping with considerable certainty, territory where the conditions are favorable and the reverse, and with less certainty the doubtful regions.

CHAPTER IV.

INDIANS.

According to the report of the Indian Commissioner for 1885 there are within the United States, exclusive of Alaska, 259,244* Indians (estimated and enumerated), of whom more than 70,000 belong to tribes in the Indian Territory and elsewhere, known as civilized.

Of these, 228,506 are found in the States and Territories west of the Mississippi (including 78,380 in the Indian Territory and 9,901 pueblos), and the balance, or 20,738, in Wisconsin, Michigan, New York, Maine, North Carolina, and Florida.

The population of the twenty-one separate wild or nomadic tribes and the twenty pueblos visited, reached in 1886, according to original observations, the reports of the Indian Commissioners, special census reports, and those made by the military authorities, an approximate aggregate of 60,000 souls.

Of these, 42,333 nomads either resided upon or were charged off to reservations, the aggregate area of which is given at 21,272,556 acres, or an allowance of 502 acres for each man, woman, and child (buck, squaw, and pappoose).

The total of the pueblos, including the Moquis, aggregate approximately 9,901, and the area of their grants and reservations now aggregates 3,415,645 acres, or at the rate of 353 acres per capita (man, woman, and child). The average for the Moquis is 1,307 acres, and for all the other pueblos, including Zuñi, 117 acres. Were the total of 60,004 Indians all on contiguous reservations, each individual would count against 475 acres.

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*The report of the Indian Commissioner for 1886 gives a total of 247,761, a reduction due to further enumeration and a closer count by the military and Indian authorities.

The following table summarizes the tribes encountered, reference to most of which may be found in the several survey reports:

INDIAN TRIBES WITHIN AREA OF SURVEY.

Number.	Name of tribe or reservation.	State or Territory.	Year visited.	Number.	Year.	Reservation area in acres.	Acres per capita.	Class.	Remarks.
1	Warm Springs	Oregon	1878	850	1886	464,000	546	Nomads, on reservation.	Warm Springs, Wasco, Tenino, John Day, and Piute.
2	Klamath	...do	1878	972	1886	1,056,000	1,086	...do	Klamath, Modoc, Walpape, &c.
3	Bannocks and Snakes.	Idaho	1877	1,444	1886	1,202,330	833	...do	Near Fort Hall.
4	Snakes	California	1878	100	1878	None.	None.	Nomads	Located northeast from Fort Bidwell.
5	Mission	...do	1875	3,096	1886	160,762	50	Semi-civilized	Serrano, Diegueño, Coahuila, and San Luis Rey.
6	Pah-Utes	Nevada	1880	2,300	1882	None.	None.	Nomads	Away from reservations.
7	Pah-Utes, Pyramid Lake.	...do	1877	1,248	1886	640,815	513	Nomads, on reservation.	
8	Shoshones and Pah-Utes.	...do	1880	2,300	1886	.....	None.	Nomads	Wandering over Nevada.
9	Piutes and others	...do	1880	100	1883	1,000	10	Nomads, on reservation.	Moapa River Reserve.
10	Goshutes	Utah	1880	256	1882	None.	None.	Nomads	
11	Pah-vants	...do	1880	134	1882	None.	None.	...do	
12	Uintah and White River Utes.	...do	1872	1,056	1885	2,039,040	1,932	Nomads, on reservation.	Estimated.
13	Uncompaghre Utes	...do	1876	1,252	1885	1,933,440	1,544	...do	Tabequache Utes.
14	Southern Utes	Colorado	1874	978	1886	1,094,400	1,119	...do	
15	Navajoes	New Mexico	1873	17,358	1886	8,205,440	473	...do	
16	Jicarilla Apaches	...do	1873	1,192	1886	474,240	398	...do	Mescalero, Jicarilla, and Mimbres Apaches, near Fort Stanton.
17	Mescalero Apaches	...do							
18	Apaches at Cañada Alamosa.	...do	1873	200	.....	None.	None.	Nomads	
19	Moquis	Arizona	1874	1,919	1886	2,508,800	1,307	Pueblos	
20	Other Pueblos	New Mexico	1874 1875	7,762	1886	906,845	117	...do	Estimated.
21	Apaches	Arizona	1871 1873	4,977	1886	2,528,000	508	Nomads	Mostly on reservations, Arivapa, San Carlos, Chiricahua, Coyotero, Mohave, Pinal Tonto, and Yuma Apaches.
22	Pimas and Maricopas.	...do	1871	5,050	1886	357,120	71	Nomads, on reservation.	Estimated.
23	Yumas (Colorado River Reservation).	California	1876	800	1886	45,500	57	Nomads	Do.
24	Mohaves and Chemehuevis.	Arizona	1875	999	1886	300,800	301	Nomads, on reservation.	202 are Chemehuevis.

INDIAN TRIBES WITHIN AREA OF SURVEY—Continued.

Number.	Name of tribe or reservation.	State or Territory.	Year visited.	Number.	Year.	Reservation area in acres.	Acres per capita.	Class.	Remarks.
25	Mohaves (Camp Mohave).	....do	1871	700	1882	None.	None.	Nomads	
26	Hualapais	....do	1871	728	1883	730,880	1,004	....do	Estimated.
27	Seviches, or Suppai.	....do	1871	214	1882	38,400	179	Nomads, on reservation.	Do.
	Total	....	......	*83,004	......	24,606,291	475		

* Of this number, 7,800 are estimated as either away from or never having been on a reservation.

The area of Indian Territory occupied by the several tribes is given at 64,223 square miles, or 41,097,332 acres, for a total of 75,805 Indians, or at the rate of 542 acres per capita. The largest average within the region of survey is 1,932 acres, in the case of the Uintah and White River Utes.

While so far as data shows the only tribes, where the average is less than 160* acres per capita, are the Mission, the Pimas, and Maricopas and the Piutes in the Muddy Valley, the Yumas, also the Pueblos, other than the Moquis.

STATEMENT SHOWING TOTAL OF INDIANS AND AREAS OF INDIAN RESERVATIONS WEST OF THE MISSISSIPPI RIVER.

Number.	State or Territory.	Number on reservation.	Area, in acres, of reservation.	Average acres per capita.	Average acres, family of five.	Number of agencies.	Remarks.
1	Arizona	21,067	6,403,181	304	1,520	2	700 Mohave not on reserve.
2	California	5,020	472,492	92	460	4	6,456 off reserve.
3	Colorado	978	1,094,400	1,119	5,595	1	None off reserve.
4	Dakota	30,740	26,847,105	873	4,365	9	Do.
5	Idaho	3,022	2,611,481	864	4,320	3	600 off reserve.
6	Indian Territory	75,805	41,097,332	542	2,710	7	None off reserve.
7	Iowa	350	1,401,258	4	20	1	Do.
8	Kansas	1,007	102,026	101	505	1	Do.
9	Minnesota	7,596	4,755,716	626	3,130	1	Do.
10	Montana	12,834	†28,169,960	2,195	10,975	6	Do.
11	Nebraska	2,823	380,187	134	670	2	Do.
12	Nevada	1,720	954,136	552	2,760	2	6,300 off reserve.
13	New Mexico	26,222	9,488,528	364	1,820	9	None off reserve.
14	Oregon	3,947	2,075,360	526	2,630	5	800 off reserve.
15	Utah	2,308	3,972,480	1,721	8,605	2	350 off reserve.
16	Washington	8,097	4,107,556	507	2,535	6	2,000 off reserve.
17	Wyoming	1,800	2,342,400	1,301	6,505	1	None off reserve.
	Total	217,079	135,172,817	623	3,115	57	Total off, 17,446.

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* This would be at the rate of 800 acres for each family of five.

† The reservation known as "Blackfoot," extending from the north bank of the Upper Missouri to the northern boundary, has an area of 21,651,200 acres for 6,693 Indians, or 3,235 for each Indian, and 16,175 acres for each family of five.

NOTE.—New York, North Carolina, and Michigan each have one agency, and Wisconsin two.

The total number of agencies west of the Mississippi River is fifty-seven, including seven for the Indian Territory. The aggregate area of Indian reservations west of the Mississippi River is about 135,172,817 acres* (211,208 square miles),† while that of the military reservations adjacent, is 1,838,054 acres.

The largest average in acres per capita, shown by the table for a single political division, is 2,185 for Montana, and the least is for Iowa.

The number of Indians west of the Mississippi River (217,079) is, when compared with the ever advancing civilized population, scarcely appreciable, while the territory held for their use is in area about five times as large as the State of New York.

It is a mooted question, at present impossible of determination, whether the Indians of the United States, as a whole, are increasing or decreasing; probably the former, in a very small ratio, either actual or relative.

Reflection makes it apparent that not only is the large area reserved greatly in excess of any actual need of the Indian, especially when their roving and predatory habits are abandoned, but also that these large tracts impede the harmonious and homogenous settlement of these regions, now being availed of for farms, homes, mines, mills, and workshops. The ever restless surging tide of population, almost a law unto itself, already in many cases crowd over the borders of these reservations, and the time is not far distant when the question of the surrender of these lands to actual settlers will naturally be answered in the affirmative, on the plea of the greatest good for the greatest number.

Assuming that there are 45,000 families of five each within the above area, and allotting to each one 320 acres, there would then remain more than ground enough for 750,000 white families, each with not less than 160 acres.

Of course great quantities of land are not available for agriculture, and statistics are not at hand, but it is safe to assume that the land that might be spared by the Indian could be made the home of 3,000,000 farmers and stockgrowers, with such number of miners as this industry shall warrant, with mechanics and men of commerce in numbers demanded by these industries, while at the rate of 50 per square mile, the possible population, after subtracting the allowance to 45,000 Indian families, would be 9,500,000.*

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* This area, as determined from a search and compilation at the Land Office, is 165,868,961 acres, or 259,170.250 square miles.

† Taken from Annual Report of the Indian Office for 1876.

Assuming an allotment of 320 acres to each family, there would remain about 120,000,000 acres of land which, at $1.25 per acre, aggregates $160,000,000, which, funded at 3 per cent., would afford an annual income of $4,800,000—an amount not greatly in deficit of the present annual estimate of the Indian Bureau.

After an allotment some land remaining would be worth more than $1.25 per acre, while considerable quantities could not be sold for that sum.†

Nothing less than an actual, practical, demarcation of the several classes of land, from an examination by experts, as a preliminary, would do justice to this subject, the favorable outcome of which would go very far toward the permanent settlement of the Indian question and the relieving of the Government and Treasury of a fiscal burden, and vexatious relations so long borne.

COST.

It is believed that the cost of the Indian service from direct appropriations (independent of indirect expenses through the War Department) has been for a period of years not far from $7,000,000 annually. The present Commissioner shows that the estimates for the fiscal years 1886, 1887, and 1888 are decreasing, reaching the sum of $5,608,873.64 for the latter. The total cost, from direct appropriations alone, of the Indian service is unknown, but it probably reaches into the hundreds of millions.

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*The average of the United States for the Census of 1880 was 17, with 254.9 for Rhode Island, 221.8 for Massachusetts, 151.7 for New Jersey, 128.5 for Connecticut, and 106.7 for New York, and less than 100 for every other State.

†The Indian Commissioner, in report for 1885, recommends bonds at 5 per cent., which would, at above estimate, produce an annual income of $8,000,000; he also advises different sizes of allotments according to "fertility, productiveness, climate, and other advantages," the purchase of remaining lands by the Government, and opening to homestead entry at 50 to 75 cents per acre (see Indian Office Report, 1885, p. iv).

General Sheridan, in his report for 1885, suggests that each family be located on 320 acres; all the balance to be bought by the Government at $1.25 per acre, the proceeds to be invested in Government bonds for the benefit of the Indians (see Report Secretary of War, 1885, Vol. I, p. 62).

He renews this recommendation in his report for 1886, and estimates an annual income of $4,480,000 for the Indians, and a saving of 170,000 square miles to the public domain.

It appears from the statement below, from the Adjutant-General's Office, United States Army, that the War Department has never made any attempt to discover the cost of its Indian wars.*

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*COST OF INDIAN WARS WEST OF THE MISSISSIPPI.

Although there has been scarcely a year since the acquisition of the territory west of the Mississippi that the troops of the United States have not been engaged in active hostilities against the Indians in that section, the separate operations to which the term "war" may be applied in a fairly military sense may be limited to the following:

I. The New Mexico Expedition, under the command of Col. Stephen W. Kearney, 30th June, 1846, to 13th February, 1847.

II. The California Indian war of 1851–'52.

III. The Rogue River, Yakima, and Klickitat wars, in Oregon, August, 1853, to June, 1856.

IV. The Cheyenne and Arapahoe troubles, August 4, 1845, to March, 1856.

V. The Navajo troubles in New Mexico, September 17, 1849, to December 18, 1858.

VI. The war of the Spokanes, Cour d'Alenes, and Pelouses, in Washington Territory, May 18, 1858, to October, 1858.

VII. The war against the Apaches in Arizona, March, 1861, to April, 1866.

VIII. The Cheyenne war of 1864.

IX. The war in Southern Oregon and Idaho, and Northern California and Nevada, 1865–'68.

X. The war against the Cheyennes, Arapahoes, Kiowas, and Comanches, in Kansas, Colorado, and Indian Territory, in 1868–'69.

XI. The Modoc war in Oregon, in 1872–'73.

XII. The war against the Apaches, in Arizona, in 1873.

XIII. The war against the Kiowas, Comanches, and Cheyennes, in 1874 and 1875.

XIV. The war against the Northern Cheyennes and Sioux, in 1876 and 1877.

XV. The Nez-Perces war, in 1877.

XVI. The Bannock war, in 1878.

XVII. The war against the Northern Cheyennes, in 1878–'79.

XVIII. The Apache war in Arizona, 1871 to 1876.

It would be difficult to reach even a fair approximation of the cost of these wars to the Government; and although most writers are in the habit of speculating upon what they denominate the "expenses attending our Indian wars," their figures can not be other than mere "guess work." "The money cost of our Government wars with the Indians," says Mr. George E. Ellis, in his "Red Man and White Man in North America" (Boston, 1882), is doubtless stated within bounds when it is estimated at $500,000,000;" and Mrs. Helen Hunt Jackson, in her "Century of Dishonor" (New York, 1881), repeats this statement with added emphasis. The first of these writers estimates the cost of the Seminole war at $65,000,000, and of the Cheyenne war at $30,000,000, and these are fair instances of the calculations of most writers on the so-called "Indian problem," who depend on such figures for the proof of their arguments. The aggregate expenses of both these wars were less than $20,000,000. (See H. R. Doc. 8, 26th Congress, 2d session.)

As a matter of fact the War Department has never made any attempt to discover the actual cost of its Indian wars. The most of them have been waged by our small Regular Army, whose expenses while in active service have seldom exceeded its peace establishment. "The extraordinary expenses due to an Indian war are generally of the same nature as the regular expenses in time of peace. They differ only in degree and are both so blended and commingled that, unless the particular circumstances attending the expenditure are matters of record or are fresh in the memory, it would be difficult for any disbursing officer to ascertain from his accounts what part of his expenditures were due solely to a state of war, and what would have been the expenditure had the troops remained in camp or garrison."—(Col. J. D. Bingham, Dec. 23, 1879.)

It was not until within the last few years that the War Department has found itself called upon to so far separate the Army expenditures as to calculate what part of them were due to Indian outbreaks

The total cost to the Government of its control (military and civil) of the Indians; and protection of settlers, is the aggregate of the above class of expenditures, increased by Land Office and other expenses directly connected with surveys, &c., of the Indian Territory and other reservations.

NOMADS.

While the survey expeditions were in the field, the reservation system was definitely developed for the whole western region, and as a result, large areas have by treaty been thus segregated from the public domain.

The fierce Indian wars, of which the Sioux and Apache conflicts are typical, have become substantially a thing of the past. The country has been netted with transportation lines, the means of tracing hostiles has improved, but above all, their war-like spirit has been broken, and little by little, stern necessity has forced an assimilation with the gentler ways of peace.

Hereafter, outbreaks will doubtless occur, when instigated by willful, turbulent, and wily leaders, but these needs must be both less frequent and violent.

The Commissioner of Indian Affairs refers to the Indian population as civilized, party civilized (those living on reservations and adopting civilized customs in part), and "blanket Indians."

The latter may, or may not, live on reservations, retain substantially their aboriginal costumes, the blanket being the principal article of dress, and to whom labor is unknown. He refers to them as ignorant, superstitious, idle, thriftless, dependent, and barbarous, but trusts that civilization

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or hostilities. In November, 1880, in response to a Senate resolution of June 21, 1879, the War Department returned certain data concerning the expenses incurred by the United States in certain Indian wars (Senate Ex. Doc. 15, 46th Congress, 3d session); and while the results of a tedious examination of the records were wholly unsatisfactory, they afford the only accurate figures that have ever been reached on the subject. The figures elicited show expenses by the Quartermaster and Commissary departments in case of Nos. IX, X, XI, XIII, XIV, XV, XVI, and XVII, as $22,717,286.77.

It is not known that any attempt has ever been made to ascertain what extraordinary expenses were incurred in the prosecution of the operations against the Apaches in Arizona. Certainly no separate report has ever been published on the subject, and no special appropriation for that purpose has ever been asked for by the War Department. Whatever expenses have been incurred have been met from the regular appropriation for the support of the Army.

may follow the introduction of agriculture* and its improvements, education, and such industries, gradually, as are most suitable.

He advocates the abandonment of tribal relations, the surrender of superstitions, the forsaking of savagery, and the adoption of white customs and industry; the education of the children, the cultivation of individual responsibility, with, finally, equal rights as citizens, when they shall no longer be "wards" of the nation.

He recommends the allotment to each family of a homestead, with the Government to assist in building houses, fences, and opening lands, the title to be held temporarily in trust, and finally in fee; other lands to be sold and proceeds funded for their benefit. He looks upon the Pueblos as objects of sympathy and guardianship, and thinks that ultimately the fifty agencies west of the Mississippi River may gradually be lessened by concentration within selected areas.

In 1869 all of the twenty-six tribes, other than the Pueblos, were nomads, and either warlike or restless upon the approach of civilization, except, perhaps, the Warm Spring, Mission, Pima, and Maricopa, Yuma, and Mohave Indians. They were essentially interior Indians, wanderers within given limits, through the mountains, plateaux, valleys, and plains; those first above mentioned cultivating somewhat the soil, others of the Great Interior Basin, subsisting in part on piñon nuts and roots, while the balance subsisted by hunting and fishing.

The total number being inconsiderable when spread over so vast a domain, land to them had no apparent limit, could not be conceived of individually, but was traditionally held as a tribal possession, from whence all foreign intruders of whatever race, tribe, or color, were unwelcome and hostile. At the same time, love for the soil, in the abstract, amounted to a passion, and life was readily sacrificed to the protection of the territory of their fathers.

The habits, characters, disposition, and language of these tribes has been made the subject of many reports, military and civil, scientific and otherwise. They are now being ethnologically considered and it is hoped that the types of this remnant of a former population will have been secured before they have become absorbed, or at least have assimilated certain of the arts of modern civilization. While their ultimate fate is certain, nevertheless the greatest amelioration of their condition is consistent with their permanent and contiguous settlement as tribes, as much massed as possible, on allotted lands, held permanently in severalty, as self-supporting inhabitants, capable of and exercising, finally, a proper local self-government. The history, yet to be written, of the contact of American civilization with the aboriginals, the subjugation of the latter, the appropriation of the lands, through conquest and "treaty," the gradual apparent decimation of these races, their amalgamation in part, and the hastening of their final extinction, furnish food for the ethnologist and philosopher, but scarcely for the practical man of affairs, intent on wresting from productive nature the largest bounty, through whose agency treaties have doubtless too often been made for Indians to misunderstand, and which the Government has been prevented from enforcing.

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*The number of acres under Indian cultivation in 1885 was 345,341, an increase of 18,473 over the previous year, with 378,376 acres for 1888.

The Indian has been denominated and treated as a ward, and at the same time as ostensibly a sovereign, treaty-making power.

He has been met by the Government, through its War Department, sword in hand, to suppress outbreak, and as sustaining the Interior Department, whose emblem has been the olive branch, while the citizen has too often stood ready to rob him of his morals and his land.

It is not at all strange that this child of wonder and fear, viewing nature and man more through the external senses, should resist the approach of civilization that apparently despoils him of most that life holds dear. This resistance, always a forlorn hope, has had its day for the Indians of the western mountains. Their warlike spirit is now broken, and these hardy sons of nature are now gradually adopting the ways of peace and civilization. The result of this control, assimilation, and gradual absorption, can better be seen a century hence than now.

While most of the war problems with the Indians have been solved, yet this arm of Government must for a long time be ready to be invoked that the Indian may accept his fate, while the Indian troubles of Alaska are also a thing of the future, which emigration and settlement may develop.

Since the wild Indians of our continent are found, upon early contact with civilization, a creature of impulse that can only be controlled through fear, it is evident that the presence of the military force is necessary to preserve and defend both the interests of the white man and Indian.

It is this great power of conservation that the military establishment possesses that has rendered possible, within so short a time, the settlement of our grand far western domain.

Wise counsel will always avail of this protecting and defending influence, of this conservating power in Government, with the Indians as elsewhere, always to the exclusion, where possible, of its more active and offensive operations. In which case experienced Army officers will, where needed, be called upon to advise, and my extended experience proves that the Indians of all tribes respect the judgment and discretion of such officers, and too often have but little respect for the authority of their agents, except where seconded by the proximity of the soldiers.

Assuming that war hands and measures are needed for the regulation and control of the wild and savage tribes met by American civilization, to prevent wars and wage them, and that the greater share of the work of this protectorate has already been done, certain suggestions occur as the result of my personal observation. The issue of rations should be stopped gradually, but finally; the Indian to be fed from the product of volunteer, hired, or enforced labor. The annuities of goods and money gradually to be suspended; the former as the Indian becomes more self-sustaining, the latter by conversion into a permanent fund in connection with the disposition of the reservation lands. Where needed they should be supplied with a nucleus of cattle, horses, sheep, goats, swine, wagons, oxen, and agricultural implements. Where labor is not voluntary, they should be hired in instances; in others made to labor, and thus through labor educated up to a use of the individual judgment.

As fast as they are able to exercise the responsibility they should be given certain of the rights as citizens, especially before local courts.

The acquisition of territory from, and the formulation of property rights, by organized authority, appears to be the only basis upon which land titles, needed for the spread of civilization, may be guaranteed, and the greater the number of small holdings for a given area the better; hence, as soon as individual heads of families are competent, they should receive land in severalty in trust for a period of years, and in fee finally.[*]

The proceeds from the sale of unnecessary lands and from temporary leases, if any, to be held in trust by the Government (the annual income to be equally distributed), until they can reach the state where they may exercise the functions of local self-government.

Therefore the reservations, wherever found, and including the Indian Territory, will finally be abandoned as such, as fast as the Indians become accustomed to the labor, duties, and privileges of civilization, and are thus self-supporting. Considered as owners of land, they are wealthy in the community sense; to educate and bring them to the condition of utilizing and preserving this wealth, in the individual sense, is one of the principal indeterminate factors of the Indian problem.

At all times every religious denomination should not only be allowed, but encouraged to missionary labors, especially with the young, and to establish schools, but entirely separate and apart from the Government. Thus it would appear, except as touching the administration of unallotted Indian lands, the temporary control of those allotted, and the trust funds during the necessary period, that the remaining functions of the Indian Bureau, not disappearing through the amelioration of the condition of the Indian, can gradually be transferred to, and absorbed by, the regular branches of the State and Territorial governments.

PUEBLOS.

The Pueblos (20 in all), including the Moquis (1,919 enumerated), and 19 others (7,762 estimated) all come within the region of survey.

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[*] By act approved February 8, 1887 (Public, No. 43), a provision is made for the allotment of lands in severalty to the Indians, to extend the protection of the laws to them, the lands allotted to be held under patent in trust for twenty-five years, or longer at the discretion of the President; also for purchasing lands not allotted thereunder, with eligibility to citizenship to any allottee under given conditions, and for making surveys and resurveys for purposes of allotment. This act further provides for the purchase of unallotted lands, upon the consent of the Indians and ratification by Congress, said purchased lands to be held for homes for actual settlers, the money therefor to be held in the public treasury for the sole use of the tribe the land of which has been bought, and subject to appropriation by Congress, with interest at 3 per cent. per annum, for the education and civilization of the Indians for whom it is held.

Their habits and characteristics are, in the main, well known, and it is believed that they are still being investigated ethnologically.

Entirely peaceful, they are well worthy the fostering care and encouragement of the Government in the cultivation of their fields, the title to which (except, perhaps, for the Moquis and Zuñi) it is believed vests in them permanently, although their exact status as to citizenship is indeterminate, and the protection of their lands by the General Government may become a necessity.

They should be aided by wagons and oxen where needed, and by agricultural implements and seeds for all.

From personal observation in a number of instances, I am aware of their strong desire for such encouragement, and these Indians, more than all others, merit the sympathy and support of the Government.

CHAPTER V.

LAND CLASSIFICATION.

As early as 1872 the instructions required observations upon the various natural resources of the area being surveyed topographically. The systematic classification of the land over conjoining areas was attained in 1874, and continued with increasing detail until the close of the field work.

The greater portion of the area surveyed having been in advance of and remote from settlement, but a small part as reached had been subdivided by the surveys of the public lands, and as all of the ground had to be traversed and viewed by the topographic parties, without appreciable additional time or cost, the measurements, examinations, and notes required as a basis for the classification were prosecuted, *pari passu*, with the principal branches of field-work.

The first use of such results was with the troops in their movements without forage supplies and the next with the General Land Office in conducting their subdivision surveys, while the use has been general for those seeking homes in these regions, and for the capitalist and investor with present or prospective interests therein.

It is not claimed that the results are more than approximate, either in quality or quantity, as much had to depend on individual judgment, especially in the line of demarcation for area, with an admixture of grazing and timber, or as to the kind of grazing.

The amount stated as agricultural in the following tables is confined to that which may either be actually cultivated without irrigation, or, irrigation being necessary, as is most usual, it has been estimated or determined that sufficient water is available. This excludes large areas the soil of which is fit for cultivation with irrigation, but for which no water is available.

As the estimates of valuable soils that may be irrigated have been kept below a minimum, it is not unlikely that at some future period the amount actually cultivated may be in excess of amounts stated, from the small local increase due to irrigation itself excluding the effect of secular changes in rainfall.

The number of divisions were finally expanded until notes on all the following natural resources were taken, which includes all classes now known to the law in its disposition of the public lands, viz:

1. Arable or agricultural: without irrigation, with irrigation (sufficient water being available), or by drainage.
2. Timber: (1) large, (2) small, with prevailing species, as pine, hemlock, spruce, fir, live-oak, cedar, &c.
3. Pasturage or grazing: (1) good, (2) bad, with species and quality of grasses.
4. Arid or barren, including "desert lands," also "salines."
5. Swamp, tide, and overflowed lands.
6. Location of the precious and economic minerals, such as (1) gold, in place or placer; (2) silver and platinum; (3) cinnabar and copper; (4) lead and zinc; (5) iron and coal; (6) tin and nickel; (7) antimony and arsenic; (8) sulphur, also mica; (9) sodium, chloride and carbonate of; (10) alum and borates; (11) peats, marls, and clays; (12) asphaltum, petroleum, nitrates, and phosphates; (13) precious stones.

On the published sheets only four divisions have been shown, because of the great expense of engraving and printing in colors, as follows: (1) arable or agricultural; (2) arid or barren; (3) timber, and (4) pasture or grazing.

The following atlas sheets have been so issued, *i. e.:* 32 C, 32 D, 38 D, 41 A, 41 B, 47 A, 47 B, 47 D, 52 D, 61 A, 61 B, 61 C, 61 C sub, 61 D, 62 A, 62 C, 65 D, 69 B, 69 D, 70 A, 70 C, 73 A, 73 C, 77 B, 77 D, 78 A, 84 B, 84 C, and 84.

The table herewith indicates the approximate percentages found in an area somewhat exceeding 175,000 square miles.

TABLE OF LAND CLASSIFICATION.

States or Territories.	Number of square miles examined and classified.	Land classification.										Atlas sheet number, or per progress-map.	Remarks.
		Arable or agricultural, with and without irrigation.	Approximate percentage of area.	Pasturage or grazing.	Approximate percentage of area.	Timber.	Approximate percentage of area.	Arid or barren.	Approximate percentage of area.	Lakes, ponds, and marshes.			
	Sq. m.	Sq. m.	P. ct.	Sq. m.	P. ct.	Sq. m.	P. ct.	Sq. m.	P. ct.	Sq. m.	P. ct.		
Idaho	4022.50	20.00	0.50	2247.85	55.90	230.06	5.70	1524.20	37.90	......	....	32 C	Issued June 10, 1881.
Idaho Wyo	4022.50	30.00	0.73	2818.10	70.06	1000.30	24.87	120.00	2.98	54.12	1.34	33 D	To accompany extra copies An. Rep. 1879.
Calif'a Nevada	4127.10	111.00	2.69	3115.10	75.55	430.67	10.15	401.29	9.66	68.63	1.70	38 D	Issued Nov. 15, 1880.
Idaho Utah	4075.29	58.50	1.43	2938.05	72.13	441.24	10.82	362.00	8.90	273.30	6.70	41 A	Issued June 30, 1881.
Idaho Utah Wyo	4075.29	971.40	23.83	1883.45	46.21	867.60	21.30	132.10	3.25	220.54	5.41	41 B	Published with extra copies An. Rep. 1878.
Calif'a	4178.42	220.81	5.30	1094.75	26.20	2632.40	63.00	146.25	3.50	75.21	1.80	47 A	Issued June 30, 1880.
Calif'a Nevada	4179.43	120.00	2.88	520.10	12.50	625.25	14.96	2227.94	53.32	678.45	16.24	47 B	To accompany extra copies An. Rep. 1879.
Do	4228.96	411.00	9.80	1122.98	26.56	1624.82	38.40	900.90	21.30	169.00	4.00	47 D	Do.
Colo'do	4228.40	89.00	2.10	560.00	13.24	2810.40	66.46	760.00	17.98	......	....	53 D	The "arid or barren" is usually above timber lines, or mountain slopes and summits. Issued year ending June 30, 1883.
Do	1590.80	125.34	8.00	906.44	57.00	477.56	30.00	71.50	4.50	......	....	53 C (P)	Published as topographical sheet only.
Do	4278.00	233.00	5.45	2217.00	51.82	1493.00	34.90	335.00	7.83	......	......	61 A	Published with extra copies An. Rep. 1878.
Do	4278.00	403.00	9.41	757.00	17.70	2223.00	51.96	895.00	20.91	......	......	61 B	Published with extra copies An. Rep. 1877.
Do	4326.29	59.67	1.37	410.21	9.48	2670.31	61.73	1186.10	27.42	......	......	61 C	Published with extra copies An. Rep. 1878.
Do	1100.00	13.00	1.20	88.00	8.00	557.00	50.60	442.00	40.20	......	......	61 C, sub	Part of sheet 61 C, San Juan mining region.
Do	4326.29	443.29	10.24	1470.00	34.00	1232.00	28.46	1181.00	27.30	......	......	61 D	Issued June 30, 1879.
Do	4278.00	291.00	6.80	2970.00	69.42	773.00	18.07	244.00	5.71	......	......	62 A	Published with extra copies An. Rep. 1878.
Do	4326.29	197.00	4.62	2773.20	64.11	1151.09	26.42	205.00	4.85	......	......	62 C	Do.
Calif'a	4420.20	67.00	1.50	2182.00	49.20	430.00	9.70	1791.20	40.60	......	......	65 D	Published with extra copies An. Rep. 1877.
Colo'do. N. Mex.	16050.52	930.66	5.80	8334.26	51.93	5836.90	36.36	957.69	5.96	......	......	69 (P)	69 B, publ'd with extra copies An. Rep. 1877. 69 D, publ'd with extra copies An. Rep. 1878. 69 (P), published topographically only.
Do	4373.74	168.00	3.84	1412.00	32.28	2536.74	58.00	257.00	5.87	......	......	70 A	Published with extra copies An. Rep. 1877.
N. Mex.	4420.20	155.00	3.51	2797.20	63.28	1328.00	30.05	140.00	3.16	......	....	70 C	Do.
Calif'a	4465.85	344.12	7.71	1052.74	23.57	723.01	16.21	1537.05	34.42	*50.98 †757.95	*1.14 †16.95	73 A	Issued June 30, 1879.
Do	4510.00	607.70	13.50	1940.90	43.00	425.00	9.70	428.60	9.50	‡172.40 †924.20	‡3.80 †20.50	73 C	Issued March 31, 1881.
Arizona	17952.24	796.24	4.40	7154.00	39.90	2614.00	14.60	7388.00	41.10	......	......	75	Published as topographical sheet only.
N. Mex.	4465.03	193.00	4.32	2537.05	56.82	1015.00	22.73	720.00	16.11	......	....	77 D	Published with extra copies An. Rep. 1877.
Do	4510.27	88.04	1.92	3300.43	73.16	933.34	20.70	188.46	4.20	......	......	77 D	Published with extra copies An. Rep. 1878.
Do	8976.12	500.00	5.57	6076.12	67.69	1200.00	13.37	1200.00	13.37	......	......	77 A & 77 C.	Published on full sheet No. 77.
Do	17952.24	781.04	4.35	11914.40	66.37	3148.34	17.53	2108.46	11.75	......	....	77	Issued year ending June 30, 1883.
Do	4465.85	84.82	1.89	3432.21	76.83	801.82	18.01	147.00	3.29	......	......	78 A	Published with extra copies An. Rep. 1878.
Arizona N. Mex.	13573.47	223.00	1.65	5850.17	43.12	4441.01	32.80	3052.00	22.43	......	......	83 (P)	Published as topographical sheet only.
N. Mex	4551.13	200.00	4.40	2154.13	47.30	1700.00	37.37	500.00	10.98	......	......	84 A	Shown on full sheet 84.
Do	4534.18	32.00	0.70	3460.27	76.49	871.00	19.20	170.20	3.70	......	......	84 B	To accompany extra copies An. Rep. 1879.
Do	4596.76	154.00	3.40	3673.00	79.90	732.76	15.90	37.00	0.80	......	......	84 C	Issued year ending June 30, 1882.
Do	4596.76	......	....	3281.76	71.39	865.00	18.82	450.00	9.79	......	......	84 D	Shown on full sheet 84.
Do	18301.78	386.00	2.11	12588.16	68.79	4169.96	22.78	1157.36	6.32	......	......	84	Issued year ending June 30, 1883.

* Water and marsh. † Chaparral. ‡ Water.

NOTE.—(P) after the atlas-sheet number signifies that only a portion of the sheet has been classified.

Of the area of 175,035.54 square miles above given, 8,358.17 square miles, or 4.77 per cent., is agricultural; 86,412.86 square miles, or 49.37 per cent., grazing; 47,159.35 square miles, or 26.94 per cent., timber; 29,659.55 square miles, or 16.95 per cent., arid or barren; 1,764.40 square miles, or 1.01 per cent., water, swamp, or marsh; and 1,681.25 square miles, or 0.96 per cent., chaparral (the latter in Southern California).

The following table gives the division of the above area, according to States and Territories:

Number.	States and Territories.	Area.	Land classification.									
			Arable.		Grazing.		Timber.		Arid or barren.		Water and chaparral.	Water.
			Sq. miles.	P. ct.	Sq. miles.	P. ct.	Sq. miles.	P. ct.	Sq. miles.	P. ct.	Sq. miles.	Sq. miles.
1	California	23,632.02	1,573.31	6.7	8,244.07	34.9	6,757.10	28.6	4,812.17	20.4	2,232.29	....
2	Nevada	6,467.01	332.18	5.1	2,725.62	42.2	142.04	2.1	2,620.77	40.3	....	605.40
3	Idaho	11,100.16	714.79	6.4	6,736.36	60.4	1,758.65	15.7	1,776.40	12.9	....	177.96
4	Wyoming	396.00	97.00	....	270.00	....	29.00	....	60.00	....	....	....
5	Utah	4,745.86	365.49	7.7	2,862.99	60.5	762.00	16.4	365.00	7.6	....	370.00
6	Arizona	28,320.20	800.94	2.7	10,422.62	36.6	5,081.01	10.2	9,855.51	37.5	....	....
7	New Mexico	66,842.96	2,106.81	3.2	41,710.16	62.5	17,942.96	26.7	5,062.89	7.6	....	....
8	Colorado	35,566.06	5,203.65	14.5	12,401.32	41.3	14,714.85	37.7	5,140.21	6.5	....	....
		175,035.54	8,358.17	4.77	86,412.86	49.37	47,159.31	26.94	29,659.55	16.95	3,445.65	

No.	States and Territories.	Atlas sheets.
1	California	47 A, 65 D, 73 A and C, and parts of 38 D and 47 B and D.
2	Nevada	Parts of 38 D and 47 B and D.
3	Idaho	32 C, and parts of 32 D, 41 A and B.
4	Wyoming	Parts of 32 D and 41 B.
5	Utah	Parts of 41 A and B.
6	Arizona	75, and part of 83.
7	New Mexico	70 C, 77, 78 A, 84, and parts of 69, 70 A, and 83.
8	Colorado	53 D, 61 A, B, C, and D, 62 A and C, and parts of 53 C, 69, and 70 A.

From the above it appears that Colorado (over 35,000 square miles examined) has the greatest arable (14.5 per cent.), the least arid (6.5 per cent.), and the largest timber (37.7 per cent.) average. New Mexico has (above 66,000 square miles examined) the least average arable (3.2 per cent.), and the largest for grazing (62.5 per cent.).

California has the least grazing average (34.9 per cent. for more than 23,000 square miles examined). Nevada has the least timber average (2.1 per cent. for over 6,000 square miles), and the greatest arid (40.3 per cent.).

It should be remarked that the several aggregate areas are unequal, and that they represent relatively the least valuable portion of each political division as regards native resources.

TABLE OF MAXIMUM AND MINIMUM PERCENTAGES FOR ATLAS SHEETS.

Largest and least averages.	Atlas sheet.	Arable.	Atlas sheet.	Grazing.	Atlas sheet.	Timber.	Atlas sheet.	Arid.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
Maximum for 175,000 square miles......	41 B	23.63	84 C	79.0	32 D	66.68	47 B	82.82
Minimum for 175,000 square miles......	84 D	0.00	61 C	3.0	32 C	5.70	84 C	0.8

The above indicates the largest and least averages for the several classes, and the atlas sheets within which they occur. It should be noted that where the arable touches zero (84 D) that the arid is only 9.79 per cent. (See Table.) Grazing and timber areas, which average for all 49.37 per cent. and 26.94 per cent., respectively, reach maxima of 79.0 per cent. and 66.68 per cent., respectively, and from these areas cultivable fields may be had by reclamation and irrigation, while tracts now arid may be made productive from the fertilization due to irrigation, even when the natural soil is in its ingredients unfit for crops.

The outlook is far more favorable to agricultural development than would appear from a superficial view, or as when observed along linear routes, traversing the plain, valley, and desert, and the Western Mountainous territory as a whole, is not by any means the arid region it might appear when viewed theoretically or in the abstract.

The probable increase of arable territory, through systematic means of irrigation, is mentioned under the headings of "Irrigation" and "Artesian Wells."

It cannot be too strongly urged that practical steps should be taken for the determination of the more exact character of the barren lands yet owned by the Government, whether subdivided or not, with a view to their final disposition to actual settlers, and gradually there should grow up a systematic classification of the mineral and vegetable kingdoms for all the lands.

APPENDIX A.

SPECIAL LIST OF LATITUDES, LONGITUDES, ALTITUDES, ETC., OF CERTAIN MILITARY POSTS WEST OF THE 100TH MERIDIAN.

NOTE.

When this volume was authorized, it had been intended that it should contain, at the date of issue, all the geographic positions (latitudes and longitudes), the result of field observations, and subsequent computations,[*] and that it should be followed by a special report, devoted principally to geographic positions alone.

Circumstances attending publication rendered it imperative that the latter volume should appear first (see Special Report on Positions, Azimuths, &c., royal 8°) which, on account of paucity of office assistance, it was impossible to render complete under any of the branches of results.

Circumstances beyond my control have precluded the possibility of exhausting the subject further, and hence this appendix has been confined simply to a list of positions determined at certain military posts.

Had time and means permitted, it would have been practicable to have compiled a list of all available mathematically determined latitudes and longitudes (coastwise and interior) in their respective orders of value, with a reference to the detailed authority for each determination and description of monuments marking these points.

Such a compilation is a prerequisite to the construction of the much-needed general military topographic atlas of the whole country.

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[*] The classes of stations, the computed positions of which were determined, are eight, as follows: (1 and 2) Main and secondary astronomical; (3) sextant latitude; (4) base lines (measured and developed); 5 and 6) primary and secondary triangulation; (7) three point, and (8) cross-sight.

TABLE I.—MILITARY POSTS, GEOGRAPHICAL POSI

Number.	Name of post.	Atlas sheet.	Latitude.	Longitude.	Altitude above sea-level.
			° ′ ″	° ′ ″	
1	Abraham Lincoln, Fort, Dak	18 B	46 46 19.00	100 50 57.00	2,211
2	Apache, Fort, Ariz	83 A	33 47 18.70	*109 57 00.00	5,001
3	Baker, Camp, Mont	14 B	46 40 44.00	111 11 00.00	4,558
4	Bayard, Fort, N. Mex. (astronomical monument)	84 C	32 47 48.35	108 09 03.77	6,067
5	Benton, Fort, Mont	6 C	47 49 38.00	110 39 45.00	......
6	Bidwell, Fort, Cal. (flagstaff)	38 B	41 51 39.04	120 09 15.56	4,647
7	Bliss, Fort, Tex. (astronomical monument)	90 B	31 45 31.14	106 29 05.27	3,630
8	Bowie, Fort, Ariz	90 B	32 10 16.20	Not reduced.	4,672
9	Cameron, Fort, Utah (first building erected 1872)	50 A	38 16 53.34	111 44 09.31	6,006
10	Cheyenne Depot, Wyo	44 C	41 07 57.77	104 49 11.65	†6,041
11	Craig, Fort, N. Mex. (flagstaff)	84 A	33 38 00.00	107 01 07.90	4,448
12	Douglas, Fort, Utah (astronomical monument)	41 D	40 45 47.50	111 50 14.07	†4,965
13	Ellis, Fort, Mont. (flagstaff)	15 C	45 40 12.45	110 58 30.97	4,747
14	Fetterman, Fort, Wyo	35 C	42 50 36.30	105 29 11.92	......
15	Fred. Steele, Fort, Wyo. (flagstaff)	43 A	41 46 56.63	106 56 54.27	†6,850
16	Garland, Fort, Colo. (flagstaff)	62 C	37 25 27.22	105 25 23.73	†7,997
17	Grant, Fort, Ariz	83 C	32 39 56.70	......	4,833
18	Hall, Fort, Idaho (flagstaff)	32 D	43 00 54.90	†112 11 40.00	4,752
19	Halleck, Fort, Nev. (astronomical monument)	40 C	40 48 34.25	115 19 34.05	5,790
20	Hancock, Camp, Dak. (flagstaff)	18 B	46 50 17.90	100 47 14.42	......
21	Independence, Camp, Cal	65 A	36 50 10.00	118 13 45.00	3,900
22	Klamath, Fort, Oreg	29 C	42 41 07.70	......	4,100
23	Laramie, Fort, Wyo. (flagstaff)	44 A	42 12 01.91	104 32 27.13	4,241
24	Lewis, Camp, Mont	15 B	47 03 47.00	109 26 36.00	3,900
25	McKinney, Fort, Wyo	34 B	43 47 05.00	106 15 12.75	4,391
26	Marcy, Old Fort, N. Mex. (astronomical monument)	69 D	35 41 19.29	105 56 45.22	6,995
27	Mohave, Fort, Ariz	74 B	35 03 00.00	114 36 36.00	706
28	North Platte Station, Nebr	45 D	41 08 18.38	100 45 58.14	2,789
29	Robinson, Fort, Nebr. (astronomical monument)	35 D	42 39 28.73	103 27 38.70	......
30	Ruby, Old Camp, Nev. (astronomical monument)	40 A	40 03 36.62	115 21 06.75	6,150
31	Russell, Fort D. A., Wyo. (flagstaff)	44 C	41 09 36.00	104 50 24.47	6,041
32	Sanders, Fort, Wyo. (flagstaff)	43 D	41 17 38.00	105 34 50.50	†7,160
33	Shaw, Fort, Mont	5 D	47 30 33.00	111 48 18.05	......

TIONS, ALTITUDES, AND MAGNETIC VARIATIONS.

Magnetic variation.	Expeditionary year.	Authority.	Remarks.	Number.
° ′ ″				
....	1874	Capt. William Ludlow, Corps of Engineers; W. H. Wood, assistant engineer.	Longitude by chronometer and sextant, latitude by sextant	1
14 10 43	1871	Wheeler	.....do	2
....	1875	W. H. Wood, assistant engineer Yellowstone Expedition.	Longitude by chronometer and sextant, latitude by sextant	3
12 56 0	1878	Wheeler	Longitude by telegraph and transit, latitude by zenith telescope	4
....	1875	Lieut. F. V. Greene, Corps of Engineers.	Northern Boundary Commission survey	5
17 53 0	1877	Wheeler	Trigonometric connection with triangulation	6
12 25 15	1876	Wheeler	Longitude by telegraph and transit, latitude by zenith telescope	7
13 47 53	1878	Wheeler	Latitude by sextant	8
16 24 0	1873	Wheeler	Trigonometric connection with triangulation	9
....	1872	Wheeler	Trigonometric connection with Cheyenne astronomical monument, altitude of astronomical monument.	10
12 59 00	1878	Wheeler	Trigonometric connection with triangulation	11
17 01 0	1872	Wheeler	By traverse line to Coast Survey station at Salt Lake City	12
19 12 0	1877	Wheeler	Trigonometric connection with astronomical monument at Bozeman, Mont.; magnetic declination for Bozeman; altitude from Northern Boundary survey.	13
....	1876	Capt. W. S. Stanton, Engineer Corps.	Longitude by telegraph and sextant from Detroit by Capt. H. M. Adams, Engineer Corps; latitude by sextant.	14
16 27 10	1872	Wheeler	Trigonometric connection with astronomical monument	15
14 07 06	1873	Wheeler	Trigonometric connection with triangulation	16
13 40 0	1872	Wheeler	Latitude by sextant	17
18 13 0	1877	Wheeler	Latitude by sextant, longitude measured on plat	18
16 21 34	1869	Wheeler	Longitude by telegraph and sextant, latitude by sextant	19
....	1873	T. H. Safford	Trigonometric connection with Bismarck observing pier	20
15 22 42	1871	Wheeler	Longitude by lunar culmination	21
19 41 0	1878	Wheeler	Latitude by sextant	22
15 24 50	1877	Capt. W. S. Stanton, Engineer Corps.	Trigonometric connection with astronomical station at camp on Laramie River.	23
....	1875	W. H. Wood, assistant engineer.	Longitude by chronometer and sextant, latitude by sextant	24
....	1877	Capt. W. S. Stanton, Corps of Engineers.	.....do	25
13 09 20	1872-3, 1877	Wheeler	Longitude by telegraph and transit, latitude by zenith telescope	26
14 45 0	1875	Wheeler	By connection with iron monument of California boundary	27
....	1874	Wheeler	Longitude by telegraph and transit, latitude by zenith telescope	28
....	1877	Capt. W. S. Stanton, Engineer Corps.	Longitude by telegraph and sextant from Detroit by Lieut. P. M. Price, Engineer Corps; latitude by sextant.	29
17 06 04	1869	Wheeler	Longitude by telegraph and transit, latitude by sextant	30
....	1872	Wheeler	Trigonometric connection with Cheyenne astronomical monument	31
15 30 0	1872	Wheeler	Connection by traverse line with astronomical monument at Laramie City	32
....	1875	Lieut. F. V. Greene, Engineer Corps.	Northern Boundary Commission survey	33

TABLE I.—MILITARY POSTS, GEOGRAPHICAL POSITIONS,

Number.	Name of post.	Atlas sheet.	Latitude.	Longitude.	Altitude above sea-level.
			° ′ ″	° ′ ″	
34	Sheridan, Camp, Nebr	26 C	42 51 08.56	102 30 46.70	......
35	Sidney, Fort, Nebr. (astronomical monument)	44 D	41 08 36.75	102 58 13.32	4,108
36	Stanton, Fort, N. Mex. (flagstaff)	84 B	33 29 35.72	105 31 38.73	6,152
37	Union, Fort, N. Mex. (astronomical monument)	70 C	35 54 24.06	105 00 51.15	6,744
38	Verde, Fort, Ariz	73 D	34 34 28.19	*111 52 00.00	3,100
39	Whipple, Fort, Ariz. (astronomical monument)	75 C	34 32 06.12	112 27 10.30	5,318
40	Wingate, Fort, N. Mex. (flagstaff)	76 B	35 28 48.47	*108 32 29.00	7,080

*Approximate.

NOTE.—Blanks in "altitude" and "variation" columns do not necessarily imply lack of field observations, the compilation

ALTITUDES, AND MAGNETIC VARIATIONS—Continued.

Magnetic variation.	Expeditionary year.	Authority.	Remarks.	Number.
° ′ ″				
....	1876	Capt. W. S. Stanton, Engineer Corps.	Longitude by chronometer and sextant, latitude by sextant	34
....	1874	Wheeler	Longitude by telegraph and transit, latitude by zenith telescope	35
13 24 0	1878	Wheeler	Trigonometric connection with triangulation	36
14 49 0	1873	Wheeler	do	37
....	1871	Wheeler	Latitude by sextant	38
....	1871	Wheeler	Longitude by lunar culminations, latitude by zenith telescope	39
14 51 27	1873-5	Wheeler	Latitude by sextant	40

† Taken from plat.

being incomplete. The altitudes marked "*l*" are from connected levels, the others from cistern barometer determinations.

Appendix B.

DESCRIPTION OF ATLAS SHEETS.

INTRODUCTION.

The following brief description of the principal published atlas sheets of the uniform series is herewith presented, in order that certain details shall become more intelligible, and that a further and more complete reference to published reports bearing thereon may be suggested.[*]

The projection chosen as the basis of construction of the several polyconic rectangles *so called* is original, and may be termed a modified secant conic projection. It will be found elsewhere described in this volume.

The 111th meridian west from Greenwich was chosen as the central line from which the several principal rectangles (ninety-five in number) were laid out on either side. The parallel 39° north latitude has been assumed as the central latitude line. Each rectangle comprises 2° 45′ of longitude and 1° 40′ of latitude. Each sheet is separately projected by the modified secant conic method, and so constructed that the number requisite to embrace an entire State or Territory may be conjoined where desirable. The scale of each atlas sheet is 1 inch to 8 miles, or 1 : 506880; for each quarter sheet 1 inch to 4 miles, or 1 : 253440. Lesser subdivisions of a single atlas sheet have been published on the scale of 1 inch to 2 miles, 1 inch to 1 mile, and an inch to two thirds of a mile. The principal positions on each sheet are checked, by the results from the main astronomic determinations, of measured and developed bases, and trigonometric positions;

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[*] This appendix (partly compiled), for which Lieutenant Macomb has rendered assistance, it has not been possible to make either uniform or complete.

the result of computations, by means of least squares. Intermediate points are checked by means of positions determined from a secondary triangulation. Minor positions are the result of trigonometric observations by the several topographic parties. Reductions from the note-books were first made by the field topographers on a large scale, usually 1 inch to 2 miles, and these are reduced in an artistic manner to the final atlas sheets. The land classification series were obtained by placing in color upon the topographic map as a base the various observed facts and relations concerning the distribution of the arable, arid, timber, and grazing lands, together with special features of lakes, marshes, etc. The geologic sheets, so far as published, are obtained by superposing upon the topographic sheet as a base the several colors defining the formations as observed and determined. The grand basins of drainage, within which the operations of the survey were conducted and from which the topographic maps have resulted, are: the Coast, Interior, Sacramento, Columbia, and Colorado, lying west of the Continental Divide; the Missouri, Mississippi, Arkansas, Brazos, and Rio Grande east of the Continental Divide (see map of "Areas of Drainage to the Atlantic and Pacific").

The aggregate of the mountainous area of these basins, all lying west of the Great Plains, is approximately 993,360 square miles.*

In 1869, when the explorations and surveys began, there had been built within the now surveyed area of 359,065 square miles of this territory, 1,637 miles of railway, including the Union Pacific Railroad, North Platte to Ogden, and the Central Pacific Railroad, thence to San Francisco; while in 1884 railroads in the same area aggregated not less than 16,000 miles.

SHEETS 32, C AND D.

These two quarter sheets form the southern half of full sheet 32 of the 1-inch to 8-mile series. The northern half was not surveyed. The territory embraced is the southeastern corner of Idaho and a narrow strip of western Wyoming.

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* See "List of reports and maps, second edition, 1881," for titles of most of the maps herein described, and also Appendix G, herewith.

Scale.—One inch = 4 miles, or 1 : 253440. Area, 8,046 square miles (4,023 square miles each).* Boundaries, 42° 20′ and 43° 10′ north latitude, and 111° to 113° 45′ longitude west from Greenwich. Adjacent sheets published: S. 41, A and B; field work during 1877 expedition.

There are six principal settlements, three Mormon and three Gentile. Fort Hall is at the northwest corner of Sheet 32 D, nor far from the Snake and Bannock Indian Agency, which lies to the southwest, at Ross Fork.

GENERAL PHYSICAL FEATURES.

With the exception of a small portion in the southeastern corner, drained by Malade Creek (a small arm of the Great Basin), the whole area belongs to the Snake River Basin and its tributaries, of the Columbia. The grand physical characteristics are the distinctions between the Basin Range systems that constitute all of 32 D, and the southeastern part of 32 C, and the Snake River Desert or Plains and their lava exposures.

The ranges proper are meridional, mostly anticlinals, with corresponding synclinals under adjoining valleys, or monoclinals, joined by ridges flanking irregularly the whole uplifted masses, which surround a number of elevated detrital valleys, usually the beds of streams, having both exterior and interior drainage. Several mountain groups border the plains of Snake River.

DIVIDES AND DRAINAGE SYSTEMS.

The most important divide is that between the Bear River portion of the Great Basin and the Columbia, of which the Port Neuf and other unnamed mountains form a part. The sub-basins are those of the Snake, Bear, and Blackfoot Rivers, each threading its way through mountain masses in cañons of various magnitudes. The ridges are crowned by many prominent peaks towering above the adjacent valleys. The Snake follows a tortuous bed eroded from a plain-like eruptive basalt field. The Utah Northern now traverses Red Rock Pass, the outlet of Old Lake Bonneville (32 D). Various other passes, as the Port Neuf, connect the several detrital valleys, ranging in altitude between 5,000 and 7,000 feet, and by means of which present and future communication becomes assured. The climate differs but slightly from that of Sheets 41 A and B, except for the more desert northwesterly section and the higher altitudes at the northeast, where a more rigorous winter and cooler summer prevails, with lower temperature for July and August. The resources, except for the exceedingly sterile desert portion, are similar to those for Sheets 41 A and B, not having yet been scarcely utilized except for a little mineral development in high altitudes at the northwest. There is substantially no game.

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* For 32 C there is (1) 1,541 square miles mountainous, (2) 223 valley, (3) 440 as plains, and (4) 1,819 desert; while for 32 D the areas for mountains, plateaus, and valleys are 1—876—807 and 1,340 respectively. There are seven ranges, one plateau, sixty-four measured or named mountain peaks (two above 10,000 feet), five valleys, two lakes, two main passes, and four cañons, the principal one being along Snake River.

LAND CLASSIFICATION.

There is found for 32 C: 5 per cent. arable, 55.9 grazing, 5 per cent. timber, 37.9 per cent. arid; while for 32 D there was noted 73 per cent. tillable, 70.08 per cent grazing, 24.87 per cent. timber, and 2 per cent. arid; also 2.34 per cent. lakes, ponds, and marshes.

It should be remarked that the percentages of arid as compared with arable would be changed somewhat in favor of the latter after all known processes of irrigation (but little practiced at present) have been applied. In sheet 5, accompanying Annual Report of 1878 (Hayden Survey), there is shown for area, in common with 32 D, geologic exposures of Silurian and Carboniferous from the Paleozoic; Triassic, Jura-Trias, and Cretaceous (Laramie group) from the Mesozoic; Tertiary (Salt Lake beds) and Quaternary of the Cenozoic; together with considerable basalt and small hot-spring deposits. The Archæan is absent, or rather covered by overlying formations, while the Tertiary volcanic rocks do not appear. The prevailing rocks of the mountain forms are compact blue limestones, calcareous shales, sandstones, and quartzites, quartzite-schists, etc. The Iowa mining district embraces the country drained by Iowa Creek, Anderson Gulch, Eagle Creek, Jack-Knife and Tin-Cup Runs, and an area of 15 miles north and south and 10 miles east and west (32 D), with Pisgah Peak (9,695 feet) as a center. Gold quartz occurs at about 6,800 feet in connection with iron, and magnetic iron is found in all the Iowa placers situated at the base of Mount Pisgah. The ores of the vicinity are iron, copper, lead, manganese, silver, and gold (see Annual Report, 1878, p. 89).

Routes.—The Utah Northern Railroad enters the area just south of Red Rock Pass (32 D), reaching 32 C near mouth of lower Port-Neuf Cañon, passing out (northeast corner 32 C) near Blackfoot, finally joining the Northern Pacific at Garrison, 454 miles from Ogden. A branch of the Union Pacific Railroad from Granger enters via Bear River, passes Bennington and Soda Springs, thence through the Port-Neuf Cañons to Pocotillo, crossing Snake River near American Falls, passing out (32 C) near 42° 45′ north latitude. This is known as the "Idaho Division" or "Oregon Short Line." The counties are the southern half of Oneida and a small portion of Bear Lake, Cassia, and Alturas. The population of Bear Lake and Oneida counties was 10,199 in 1880, with 1,937 for the settlements within the atlas sheets.*

SHEETS 38, B AND D.

These together form the eastern half of the full sheet of the same number.

Locality.—Parts of northeast California, northwest Nevada, and southern Oregon.

Scale.—1 inch = 4 miles, or 1 : 253440—Area: 8,202 square miles. (38 B = 4.075; 38 D = 4.127).† Boundaries: 40° 40′ and 42° 20′ north latitude, and 119° 15′ to 120° 37½′ longitude west from Greenwich. Adjacent sheets published, S. 47 B. Field work during expeditionary years of 1877–'78.

GENERAL PHYSICAL FEATURES.

At least two-thirds of the eastern portion belongs to the Great Basin, the western rim of which (marked by the Warner Range from Sugar Loaf Peak at the north to about latitude 41° north, thence by isolated groups) traverses the area nearly north and south, and the remainder to that of the Sacramento.

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* Taken from Rand, McNally & Co.'s Atlas. See also Annual Report 1878. The rain-fall at Fort Hall (See Signal Service Report, Senate Ex. Doc. No. 91, 50th Cong., 1st sess.) taken from observations from May, 1871, to December, 1880, gives a mean of 17.51 inches, a maximum of 21.77 inches, 1880, and a minimum, of 9.67 inches 1873.

† Of the 2,978 square miles in California 925 are mountainous, 893 plateau, 668 valley, 262 plains, and 230 desert; 3,694 square miles fall in Nevada, of which 1,193 are mountainous, 486 plateau, 836 valley, 398 plains, and 800 desert; the balance (1,582 square miles) in Oregon, embraces 315 square miles mountainous, 567 plateau, and 700 desert.

The combined area is made up of a number of ridges of the Basin Range series, together with mountain groups flanking in echelon the line connecting the northern extremity of the Sierra Nevada and the southern of the Cascade Ranges.

The mountain forms are strewn in rich confusion, and with the plateaus constitute more than half the area, the balance consisting of valley-like plains, sparsely vegetated, and wanting in drainage lines.

The principal divide, following the Warner range and its continuation for the greater part of its line of demarkation, is that between the Great Basin and the Sacramento. The sub-basins are the Upper Pitt River, Surprise Valley, and a number of alkaline flats or plains, also minor basins and reservoirs, such as are common in the more sterile regions of the interior.

The only ranges are the Warner and Granite, the other elevated forms being masses of outlying hills and broken plateaus or mesas (mostly volcanic) traversed by cañons. From a total of sixty-six principal peaks none exceed 10,000 feet, while at least seventeen are between 5,000 and 10,000 feet There are ten principal valleys, sixteen lakes (also a large number of alkali or mud flats, dry except during the rainy season), nine passes,* and nine cañons. The only rivers are the north and south forks of the Pitt. The climate has the marked wet and dry seasons of the Great Basin, all the rain falling during the winter. The area of 38 D is composed of 2.8 per cent. agricultural, 75.5 per cent. grazing, 10.4 per cent. timber, 9.8 per cent. arid or barren, and 1.7 per cent. water surface.

Irrigation is necessary for crops, and is limited mainly by the water available from streams, the sources of which lie in the mountains and high lands.

Grazing predominates. Timber is mostly used locally. Artemisia fringes the valleys and foot-hills persistently. The native resources are scarcely touched upon. Agriculture, with a little mining, is so far the only industry. Salt is produced in moderate quantity. The lake beaches are alluvial and lacustrine. The remnants of ancient glacial action are prevalent Volcanic croppings abound in the Great Basin area. No fossils were collected. At least one half belongs to the Great Basin. There are only three settlements of any importance. Fort Bidwell is located in the north central part of 38 B. Its post hospital meteorologic summary from January, 1871, to July, 1883, gives a mean annual temperature for that period of 51.1° Fahr.; a mean annual precipitation of 16.37 inches, the greatest occurring in December and March; the highest temperature 97 °Fahr., occurring in August, 1881, and the lowest — 18° Fahr., in January, 1883. There is no railroad within the area. King shows the Granite Range (38 D) as eruptive granite (Archæan), with a little basalt at the southeast, all flanked by Upper and Lower Quaternary, with basalt for the Madeline mesa to the west.[*]

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* See list of passes hitherto.

SHEETS 41, A AND B.

These sheets form the northern half of the same numbered full sheet.

Locality.—Parts of southeastern Idaho and northern Utah.

Scale.—1 inch to 4 miles, 1:253440. Area, 8,150 square miles. Boundaries, 41° 30′ and 42° 20′ north latitude, and 111° and 113° 45′ longitude west from Greenwich. Adjacent published sheets, N. 32, A and B. Field work in season of 1877.

There are thirty-six Mormon and twenty railroad (Union Pacific, Central Pacific and Utah Northern railroads) settlements within the area.

GENERAL PHYSICAL FEATURES.

The larger area lies within the Great Basin; the Great Salt Lake being the reservoir of the streams, while the balance is drained by minor streams leading to Snake River.[†] It is characterized by orographic disturbances, resulting in Basin Range upheavals, here mostly serrated meridional ridges, with the marked exception of the Clear Creek Range, having an east and west axis. The mountain and plateau forms embrace more than half the area; the balance consisting of detrital valleys and plains, through which the precipitated waters reach, either an interior reservoir or gravitate to the far-distant Columbia and the sea. One of the northern arms of the Great Salt Lake occupies the central southern part of 41 A.

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[*] For further description, see Annual Reports 1877, 1878 and 1879, and Vol. V. For Lakeview, Oreg. (elevation 5,000 feet), the Signal Service gives rain-fall for three years ten months, from November, 1883, to November, 1887, an average of 18.03 inches.

[†] The territory pertaining to Idaho contains 1,674 square miles mountainous, 164 square miles plateau, and 1,422 square miles valley lands; while that for Utah consists of 2,403 square miles mountainous, 243 plateau, and 2,244 of valley. There are not less than nine principal mountain ranges, with sixty-six prominent peaks (two above 10,000 feet), nine valleys, seven main passes, two cañons, and seven lakes.

The principal divide is that between the Great Salt Lake integer of the Great Basin and the Snake River drainage of the Columbia. The minor basins are all tributary to the above lake, the most humid of all the sub-basins of the "interior."

Much of this area was covered in earlier Quaternary times by what is now known as "Old Lake Bonneville," which had one of its outlets in northern part of 41 B.

The climate, although north of the fortieth parallel, is typical of the interior central plateau, having its marked wet and dry seasons, with a small but irregular rain-fall, severe mountain winters; the valleys in the main being habitable for stock on outdoor winter ranges, while except for a few days in August, the summer climate is delightful, and the winter, at not exceeding 7,000 feet, comparatively mild and uniform. Agriculture is the principal industry developed by the Mormons. Crops require irrigation, and it is believed that the available water supply is in deficit of available alluvium. Hence the agricultural capacity is limited, the mineral resources comparatively undeveloped, while it is already traversed by railroads, and manufactures are comparatively unknown. Game, except near mountain summits, is rare; salmon are most plentiful in the northern streams in spawning season, and trout abound.

LAND CLASSIFICATION.

Sheet 41 A is found to contain approximately 1.45 per cent. arable territory, 72.13 per cent. pasturage or grazing, 10.82 per cent. timber, while 8.9 per cent. are arid, with 6.7 per cent. of lakes, ponds, and marshes. Sheet 41 B contains 23.83 per cent. arable ground, 46.41 per cent. of grazing, 21.3 per cent. timber, and 3.25 per cent. arid or barren; also 5.41 per cent. lakes, ponds, and marshes.

The Mormons have practiced unsystematic ditch irrigation to great advantage, the soil being found rich and productive. It has been assumed that the rain-fall in this and adjoining areas in Utah and southern Idaho has been increased since the practice of irrigation. There is no proof of change due to this cause alone (theoretically there is a small re-precipitation), and can be none until the true relations between the secular cycle of rain-fall, and the intervening wet and dry stages, have been determined by instrumental observations.

Geologic.—King defines the Raft River Range and the ridges south of Kelton, with small masses between, as of the (Carboniferous) Lower Coal Measures (mostly heavy bedded blue and gray limestones), as also the Promontory Range; the balance south of latitude 41° 45′ N. as Upper and Lower Quaternary with Lower Carboniferous, Sub-carboniferous, Devonian, Silurian, and Carboniferous for this part of the Wahsatch, and Eocene Tertiary for the plateau west of Randolph; *i. e.*, types of the principal formations above the Archæan except the Cretaceous. Archæan exposures, presumably elsewhere buried, are noted at the base of the Wahsatch northward from Ogden; also south nearly to Salt Lake City. At the head of Miner's Cañon, southward from Black Pine Peak (41 A), mining operations had been conducted with considerable activity. Deposits of coking coal of excellent quality occur on Twin Creek (41 B) about 2½ miles from Bear River, where croppings are numerous, some being exploited. Farther eastward, in the tertiary foot-hills, are croppings of a light, highly lustrous, bituminous, non-coking coal, while 20 miles southeasterly, from sandstone bluffs facing Green River Basin, are croppings of mammoth bituminous veins.

Routes.—The Central Pacific Railroad enters near Corinne, thence via the northern swampy and marshy shores of the lake to Kelton, emerging at Terrace. The Oregon Short Line (see 32 C and D) enters via Snake River, thence proceeding to Soda Springs (32 D).*

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* The counties in Idaho are parts of Cassia, Oneida, and Bear Lake, and portions of Box Elder, Cache, and Rich in Utah. The population (1880) was 23,456 (approximate) or a mean of 2.58 per square mile.

The following was then the population of the principal Mormon towns: Logan, 2,370; Hyram, 1,234; Wellsville, 1,194; Richmond, 888; Smithfield, 1,100; Malade, 1,650; Franklin, 800, and Bloomington, 500. There were fifty-four post-offices. In Cache County the number of important farms was 908, with 50,839 acres under cultivation, and in Rich and Box Elder Counties, respectively, one hundred and fifty-three and five hundred and thirty-three farms and 18,397 and 22,097 acres cultivated. For further description see Annual Report, 1878, and Vol. V. The rain-fall at Corinne for nine years three months, between January, 1871, and November, 1887, was: Average, 10.36 inches; maximum, 18.95 inches, 1884; minimum, 7.07 inches, 1886. At Kelton, for six years three months, between July,

SHEETS 47 A, B, AND D.

Locality.—Parts of north central, eastern and northwestern California.

Scale.—One inch = 4 miles or 1 : 25340. Area, 11,585 square miles. Boundaries, 39° 0′′, 39° 50′ and 40° 40′ north latitude, and 119° 15′, 120° 37½′ and 122° 0′ longitude west from Greenwich. Adjacent published sheets: N. 38 D. Topography executed during 1876, 1877. and 1878.

These quarter sheets constitute the eastern half and northwest quarter of Sheet 47. There are nineteen principal settlements, thirteen in California, and six in Nevada.

GENERAL PHYSICAL FEATURES.

All that portion east of the Sierra Nevada summits and their continuation northward belongs to the Great Basin, the balance, including 47 A, forming part of the coast drainage, the streams being tributary to the Sacramento.[*] The most noticeable features are the northern end of the Sierra Nevada, members of the Basin ranges, and outliers of various trends, shapes, and forms between the Sierra Nevada and Cascade Ranges.

The mountain exposures cover more than half the area, the balance consisting of valleys and plains, which toward the coast are traversed by many minor drainage lines.

The maps give a correct expression of the physical features. The principal divide, running northerly and southerly, is that between the Great Basin and the Sacramento, which follows the water-shed of the upper Sierra Nevada, and the uplifts reaching in echelon northwesterly toward the Cascade.

Through this area the Central Pacific Railroad winds its way, making the long traverse of a pass in the northern sierras, while the maps point out

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1881, and November, 1887, was: Average, 6.07 inches; maximum, 11.74 inches, 1884; minimum, 2.12 inches, 1882. At Terrace, for six years two months, between July, 1881, and November, 1887, was: Average, 4.25 inches; maximum, 9.47 inches, 1884; minimum, 1.08 inches, 1887. See Signal Service Report.

[*] For sheets 47 B and D the number of square miles in California is 3,811, divided as follows: 1,580 mountainous, 1,416 valley, and 815 desert, while the balance of 4,596 square miles in Nevada consists of 1,940 mountainous, 1,380 valley, and 1,276 desert. There are four principal ranges, three groups, one hundred and sixty-eight prominent peaks (two above 10,000 feet), and thirty-five lakes, as well as seven passes and a number of cañons.

the possibility of better grades farther northward. The climate is divisible into three varieties, one, attaching to the mountains, a second to the valleys of the Great Basin, and a third to the lower levels of the Sacramento. The rainfall is greatest in the mountains and least in the Great Basin. Red Bluff (southwest corner sheet 47) is the nearest station at which a summary is available. Signal-Service observations from July, 1877, to July, 1883, give a mean annual temperature of 62.8° Fahr., with 110.5° Fahr. for the highest in August, 1878, and 25° Fahr. as the lowest in January and December, 1878; also December, 1879 and 1882, with a mean annual rainfall of 30.84 inches, the greatest occurring in January, with southerly prevailing winds, for spring and summer, and northerly for autumn and winter.[*]

Scarcely any of all this area is susceptible of economic cultivation, the main resources being mineral and timber. Here are found large hydraulic mines, now being persistently exploited, together with numerous gold lodes worked on a continuous and extensive scale, together with the famous Comstock lode, the history of which is well known. Naturally the Great Basin area requires irrigation, although small mountain valleys may be cultivated without. Irrigation is practiced on a small scale and without regular system. Of large game the region is destitute, while the few remaining fish are confined to near the sources of the streams. Wild geese, ducks, white and blue herons, and sea gulls are found in great numbers about the lakes.

LAND CLASSIFICATION.

Sheet 47 A is found to contain 5.5 per cent. tillable land, 26.2 per cent. grazing, 63 per cent. of timber, 3.5 per cent. arid; also 1.8 per cent. lakes, ponds, and marshes. Sheet 47 B consists of 2.87 per cent. arable, 12.59 per cent. grazing, 14.96 per cent. timber, 53.32 per cent. arid, together with 16.24 per cent. lakes, ponds, and marshes; while 47 D comprises 9.8 per cent. arable, 26.5 per cent. grazing, 38.4 per cent. timber, 21.3 per cent. barren, together with 4 per cent. lakes, ponds, and marshes.

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[*] Signal-Service rain-falls are given as follows: Red Bluff, sixteen years three months, from September, 1871, to November, 1887: Average, 23.99 inches; maximum, 61.65, 1877–'78 (*), and minimum, 13.52, 1872–'73 (*). Truckee, seventeen years one month, from September, 1870, to November, 1887: Average, 28.09 inches; maximum, 47.21 inches, 1871–'72 (*), and minimum, 13.86 inches, 1882–'83 (*). Cisco, seventeen years one month: Average, 55.10 inches; maximum, 80.46 inches, 1880–'81, (*) and minimum, 34, 1876–'77 (*). [(*) Seasonal from September to August, inclusive.] Carson, nine years nine months, from January, 1875, to December, 1886: Average, 11.75 inches; maximum, 18.03 inches, 1875, and minimum, 7.05 inches, 1883. Reno, six years three months: Average, 4.58 inches; maximum, 6.17 inches, 1884, and minimum, 2.95 inches, 1885. Wadsworth, six years four months, from July, 1881, to November, 1887: Average, 4.48 inches; maximum, 5.72 inches, 1887, and minimum, 2.75 inches, 1883. Also, Old Fort Churchill, for three years nine months, from January, 1862, to May, 1867: Average, 7.43 inches.

It is believed that steps are being taken to irrigate the Sacramento Valley through State intervention.

The Fortieth Parallel Survey gives for the Truckee, Lake, and Virginia Ranges and other parts of eastern 47 B and D, Archæan, Triassic, Tertiary, and Quaternary formations, with exposures of eruptive granite, basalt, and older lavas. The Silurian, Carboniferous, Jurassic, and Cretaceous (the latter not found west of the Wahsatch) are wanting. The Archæan crops (very slightly) in the Truckee Range only. The older volcanic rocks are Trachyte, Rhyolite, Diabase, Quartz Propylite, Melaphyr, Dacite, and Andesite. Both Upper and Lower Quaternary are present. The result of glacial action is notable along the flanks of the Sierra. Mention is made of the Eagle and Meadow Lake districts in the annual report (1878). The numerous hot springs in vicinity of Lassen's Butte are described by Lieutenant Tillman (p. 212, Annual Report, 1879) and Steamboat Springs by Lieutenant Macomb (p. 1283, Annual Report, 1877). The population as determined from the Tenth Census for the portions of Shasta, Tehama, Butte, Plumas, Sierra, Nevada, and Placer Counties, Cal., embraced was 11,065, while that for Washoe, Storey, and Ormsby Counties of Nevada was 27,966 for the territory described.

Routes.—The Central Pacific Railroad enters east of Wadsworth and emerges near Cisco. At Reno the Virginia and Truckee Railroad connects with Virginia City. From Mound House the Carson and Colorado Railroad follows the Carson River to Dayton, near which it passes out. (See sheet 57; see also Annual Reports 1877-1879, and Vols. V and VI.)

SHEETS 48 C AND D.

Locality.—Part of west central Nevada.

Scale.—One inch = 4 miles, or 1 : 253440. Area, 8,458 square miles. Boundaries, 39° and 39° 50′ north latitude and 116° 30′ and 119° 15′ longitude west from Greenwich. Adjacent published sheets, W. 47 D; S. 57, E. 49. Field work during 1876.

These quarter sheets, constituting the southern half of sheet 48, fall entirely in the Great Basin, belonging to the Humboldt, Carson, and Walker River drainage. There are four principal settlements.

GENERAL PHYSICAL FEATURES.

These are typical of the Great Basin. The streams are all without ocean outlets, many sinking before the valleys are reached. This area falling entirely within the Basin Range system, consists of a number of ranges, mostly meridional, joined by irregularly disposed divides, the whole holding within their perimeters detrital valleys and desert plains of their own building and upon which the visible mountains appear to rest, constituting a section among the most uninviting parts of the central interior of the Great Basin, scarcely susceptible of cultivation, but stored with minerals.[*]

The divides are those between the several valleys and plain-like spaces, with drainage lines, of which the most notable are the Carson, Walker, and Reese Rivers. The subordinate streams of this desiccated region are few and confined to the mountain-heights and their foot-hills.

The climate, except for its extreme dryness, is very equable. The winter, unless for altitudes above 8,000 to 9,000 feet, is not usually severe, while the summer climate along the flanks of the valleys and within the cañons is decidedly even, without high temperatures and with cool nights. Winnemucca, Nev, is the nearest point at which a meteorological summary is available, which from July, 1877 to June, 1883, shows a mean annual temperature of 48.6° Fahr., with a maximum of 104° Fahr. in July, 1887, and minimum of 20° Fahr. in December, 1879, an annual average precipitation of 8.31 inches, the greatest in January, the prevailing winds being southwest.[†] Crops could be matured, were water available, at elevations not exceeding 7,500 feet, however, the paucity of water determines only a mining future, the exception being grazing and timber. Systematic search for the precious metals has not yet been begun within the area of a very great number of mountain ridges, therefore no one can point out with certainty the future of this somewhat erratic industry, but it is safe to assume that more intelligent examination of surface indications and their connection with geologic formations known to contain ore concentrations, will eventually lead to the development of hidden wealth not at present suspected, and verify the statement that the ground of the western mountains from a mineral standpoint has not yet been "scratched."

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[*] There are four principal ranges, five mountain masses, several groups of hills, among which are sixty-nine prominent peaks, ten above 10,000 feet, with and without names. There are twelve main valleys, three lakes, and nine passes.

[†] For eight years eleven months, from July, 1877, to December, 1887, the Signal Service gives for rain-fall at Winnemucca: Average 7.93 inches; maximum 11.80 inches, 1885, and minimum 5.77 inches,

King shows for the area north of 30° 30′ a small exposure only of Archæan in the Reese River Range; no Cambrian, Silurian, or Devonian; Carboniferous, Triassic, and Jurassic (the latter small), and Quaternary. The lavas other than Basalt, are Trachyte, Porphyry, Rhyolite, Andesite, Diabase, and Diorite. The Toyabe Range is based on eruptive granite, then Weber Quartzites and Carboniferous, large exposures of Rhyolite, slight of Miocene, surrounded by Quaternary. The Desatoya Mountains are principally Rhyolite with Triassic beds. The Augusta Mountains are likewise of Rhyolite, with masses of Trachyte, Andesite, and Diabase. The Pah-Ute Range is granite at bottom, with beds of Trias, and the Kaw-soh Mountains are Basalt. Remains of old lake beaches are noted in many of the valleys, and "Lake La Hontan" in Quaternary times covered the greater part of sheet 48 C. (See Monograph XI, U. S. Geological Survey—Russell.)

The Ione, Union, Mammoth, and Lodi mining districts are mentioned in Annual Report, 1877; silver-bearing ores are found north of New Pass, and in Vol. III, Fortieth Parallel Reports, pp. 336 and 349, is found reference, respectively, to the Kingston and Reese River districts (48 D). The Genoa Hot Springs receive mention by Lieutenant Macomb (Annual Report, 1877, p. 1283).

Routes.—The Central Pacific Railroad traverses the northwest corner (48 C) en route from Winnemucca to Reno. The Nevada Central (south-

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1878. Austin, for two years nine months from December, 1877, to September, 1880: Average 10.21 inches; and Hot Springs, five years ten months, from July, 1881, to November, 1887: Average 3.26 inches; maximum 4.49 inches, 1882, and minimum 1.42 inches, 1883.

ern terminus at Austin) follows the Reese River Valley northward to Battle Mountain Station on the Central Pacific Railroad (90 miles). In the southwest corner (48 C) the Carson and Colorado Railroad enters near Larres Wells and continues southward toward Walker Lake.*

SHEET 49.

Locality.—Parts of eastern Nevada and western Utah.

Scale.—One inch = 8 miles, or 1 : 506880. Area, 16,814 square miles. Boundaries, 39° 1′ to 40° 40′ north latitude and 113° 45′ and 116° 30′ longitude west from Greenwich. Adjacent published sheets: E. 50, SE. 59, S 58, SW. 57, W. 48. Expeditions of 1869 and 1872. There are seven principal settlements. The military post (Old Fort Ruby) had not been abandoned in 1869.

GENERAL PHYSICAL FEATURES.

Integers of the basin mountain system, consisting of meridional ranges and groups, together with detrital valleys and plain-like desert tracts, constitute the area which lies entirely within the Great Basin.

Among the subordinate basins may be mentioned that of the Humboldt, while the balance represents a number of sub-basins, the streams in which either sink before reaching the valley beds or enter reservoirs such as Ruby and Franklin Lakes of Ruby Valley. The whole area is traversed in nearly a northerly and southerly direction by orographic systems of meridional uplifts, prominent among which are the Piñon, Diamond, Humboldt, Long Valley, Egan, Schell Creek, Toano, and Snake Ranges. Many prominent groups of mountains are found interspersed within its borders. The broad and deep detrital valleys have resulted from the building and subsequent erosion of the great mountain masses, the principal part of the latter occurred since these valleys were the beds of ancient Quaternary lakes, as "Bonneville" and "La Hontan."

The only divide of importance is that between the Humboldt and the series of small detached basins to the southward. The drainage is all interior, and consists of all deposited moisture remaining after evaporation and translation hence by prevailing winds, which reaches finally surface or subterranean reservoirs. Communications along north and south lines are simple, while those east and west are through passes, often difficult and considerably far apart.*

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* There was (1880) a total population of about 3,067, or 0.36 per square mile. The area embraces nearly all of Churchill, one-half of Lander, and small portions of Eureka, Nye, and Lyon Counties. There were thirteen post-offices. The principal towns are Austin (2,150) and Hillwater (214), the county seats of Lander and Churchill Counties, respectively. See also Annual Report 1877 and Vol. V.

The climate is typical of the Great Basin, with its valleys rising in altitude from 5,000 to 8,000 feet, the summits exceeding 13,000 feet (central latitude = 40° north). The winters, except at elevations above (approximate) 8,000 feet, are not severe, while the summers are cool, yet with sufficient thermal power to produce crops even at the northern limit of the sheet, wherever the rain-fall is sufficient or water may be artificially supplied. Similar to other portions of the Great Basin, the rain and snow fall is but small; the reservoirs of snow, although accumulated on a large scale in winter, are soon dissipated, and but few, if any, of the high mountain summits hold snow spots during the entire year.

The permanent resources of this territory must be largely mineral. The several valleys have been occupied, where practicable, as stock ranches; isolated points and areas have been occupied for farming purposes, while timber answers for local markets. Ruby Valley is one of the largest arable sections in all Nevada. No systematic land classification was made. The White Pine district, flourishing in 1869, has shown but little subsequent development, while the Eureka mines have proven extremely rich and valuable. The normal water supply is swallowed by the eager earth.

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* There is a profusion of prominent peaks, mostly unnamed. There are four principal lakes, numbers of alkaline flats, five passes, and four important cañons; the only river being the Humboldt, with creeks in abundance.

The following districts have been worked with varying but indifferent success:

No.	Name of district.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north.		
			° ′	° ′		
1	Cave	G. M. Wheeler	115 25	40 10	On Ruby Hill	Progress Rep., 1869.
2	White Pine	do	115 30	39 15	White Pine Range	Progress Rep., 1869, p. 8.
3	Robinson	do	114 55	39 15	Egan Range	Progress Rep., 1869, p. 9.
4	Snake	do	114 10	39 00	Snake Range	Progress Rep., 1869, p. 10.
5	Sacramento	do	114 16	39 10	do	Progress Rep., 1869, p. 11.
6	Hercules	do	114 55	39 20	Egan Range	
7	Railroad	do	116 00	40 30	Piñon Range	Progress Rep., 1871, p. 35.
8	Mineral Hill	do	116 05	40 12	do	Do.
9	Diamond	Several	115 45	39 50	Diamond Range	Progress Rep., 1871, p. 36.
10	Racine	do	115 30	40 00	Humboldt Range	Do.
11	Eureka	G. M. Wheeler	115 56	39 58	Diamond Range	Progress Rep., 1871, p. 37.
12	Sierra	Several	116 17	39 18		Do.
13	Pinto	do	115 50	39 25	Diamond Range	Do.
14	Spring Valley	G. M. Wheeler	116 05	39 35		Progress Rep., 1871, p. 39.
15	Antelope	do	116 05	40 05		Do.
16	Schell Creek	G. K. Gilbert	114 41	39 47	Schell Creek Range	Progress Rep., 1872, p. 26.
17	Ruby Hill	do	114 35	39 40	do	Do.
18	Silver Mountain	do	114 25	39 45	do	Do.
19	Piermont	do	114 32	39 30	do	Do.
20	Eagle (Old Kern)	E. E. Howell	114 07	39 42	Kern Mountain	Progress Rep., 1872, p. 27.
21	Clifton	G. K. Gilbert	113 50	40 00	Deep Creek Range	Progress Rep., 1872, p. 21.

The little probing in the above-mentioned districts had been insufficient to determine as to their permanent character.

The Fortieth Parallel reports give for the area north of 39° 45′ north latitude the succession of geological formations from the Archæan to the Quaternary, except Triassic, Jurassic, Cretaceous, and Miocene Tertiary; with exposures of Eruptive Granite, Trachytes, Rhyolites, Quartz Porphyry, Diorite, Dacite, Andesite, and Basalt.* The Cortez Range consists principally of Granites and Carboniferous, flanked by Pliocene, and surrounded by Quaternary. The Piñon Range shows successively the Cambrian, Silurian, Carboniferous, Eocene, Pliocene, and Quaternary, with Trachyte, Rhyolite, and Basalt beds. The Diamond and Egan ranges are principally lower Carboniferous. The Humboldt Range consists of Archæan, Devonian, Sub-Carboniferous, eruptive Granites, and Pliocene, surrounded by Quaternary, with small Trachyte exposures. In the northeast corner appear upper and lower Carboniferous, Granites, large Rhyolite, and Quaternary areas. Thermal and mineral springs frequently occur, the result of deep-heat or sub-surface chemical action.

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* For kinds of rocks observed for the various strata, see Vol. I, Fortieth Parallel Reports, p. 544.

Routes.—In the extreme northwest corner is the Central Pacific Railroad; at Palisades the Eureka and Palisade Railroad runs to Eureka (90 miles). The old overland stage route enters north of fortieth parallel, following the Western Union telegraph line, emerging at Grubbs Wells. It is the main eastern and western stem, from which laterals feed where required

The population was (1880) about 10,240, or an average of .61 per square mile, with twenty-eight post-offices.*

SHEET 50.

Locality.—Central and western Utah.

Scale.—One inch = 8 miles or 1 : 506880. Area, 16,814 square miles. Boundaries, 39° and 40° 40′ north latitude, and 111° and 113° 45′ longitude west from Greenwich. Adjacent published sheets: E. 51, S. 39, SW. 58, W. 49. Surveyed during 1872 and 1873. The principal settlements are Mormon, and lie westward of the southerly trend of the Wahsatch in the valleys of Great Salt and Utah Lakes and those bordering the Sevier Lake desert.

GENERAL PHYSICAL FEATURES.

Basin Range mountains west of the Wahsatch constitute the principal orographical features with meridianal axes, being usually sharply defined ridges with abundance of foot-hills.

The balance of the area consists of high basin-shaped detrital valleys and desert like plains. All except a small territory at the eastern edge of the sheet belongs to the Great Basin, its limiting line at the east being the serrated summits of the Wasatch and Snowy Ranges. The westerly third of the sheet is of an exceedingly desert character, the arable portion being a north and south strip centrally disposed and limited to the bottoms of the valleys and streams leading thereto after emergence from foot-hills and mountains. There are fifteen prominent ranges, which together, with certain mountain and plateau forms, constitute the orographic features of this exceedingly interesting mountainous region. The most noticeable range is the Wahsatch, substantially monoclinal in structure, dipping eastwardly from 25° to 30°, with the exception of Nebo Peak, which appears to be mainly a residual anticlinal. King is authority for 56,000 feet of conformable stratified rock, from the Azoic to and including the Triassic, as the basis of the structure. He also reports a practically inexhaustible supply of Coal in the Cretaceous and Tertiary found to the eastward. Through immense cañons of great abruptness traversing this range and emerging through bold openings to the interior valleys, several streams, like the Weber, Provo, and Spanish Fork Rivers, take their rise in subordinate elevations to the eastward. The principal rivers are the Jordan, Provo, San Rafael, and Sevier, while of creeks and minor streams there is an abundance. The principal divides are the sub-water sheds of the Great Basin, lying between the Great Salt and Sevier Lake drainages.

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* For further descriptions see Progress Reports, and vols. 3 and 5.

These lakes are the reservoirs of the water remaining and not carried off by evaporation and wind-carrying agencies. The valleys are mainly well settled and tilled by thrifty Mormons. Strawberry Valley, although too high for cultivation at this latitude, is rich in grazing. The Great Basin valleys are detrital, while those belonging to the Colorado basin are of erosion. There are twelve principal peaks, nearly all above 10,000 feet, a number of lakes, passes, and cañons.

The climate is typical of the Great Basin at or near the fortieth parallel. The following summary from March, 1874, to July, 1883, taken from the records of the Signal Office (station Salt Lake City) gives for mean annual temperature 51.3° Fahr., mean relative humidity, 43.7; average precipitation, 17.26 inches; prevailing winds, northwest. The highest temperature (101° Fahr.) occurred in August, 1875, and the lowest (—10° Fahr.) in December, 1879.*

The agricultural resources have been well developed by the Mormons, ditch irrigation being used, as also the grazing, but little, however, of the timber. The Mormons have discouraged mining, which, yet in its infancy, has been confined to so-called Gentile enterprise. Vast coal-fields abound in the southeastern portion, especially bordering Sam Pitch Valley, and along the southern edges of Castle Valley. The lowest elevation is Great Salt Lake, 4,195.2 feet. The valleys rise upward to 7,700 feet; the culminating peak is Nebo, 11,992 feet. Most of the ranges are mineral bearing. The old river-bed below the sink of the Sevier northward is believed to be the drainage line of the waters of the Sevier Basin to the Great Salt Lake during the last stages of subsidence of Old Lake Bonneville (see "Bonneville" chart).

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* The Signal Service gives further, for Salt Lake City for twenty-two years three months, from February, 1857, to December, 1877: Average rain-fall 21.2; maximum 38.90 inches, 1866, and minimum 10.94 inches, 1860. Deep Creek, for two years eight months, from September, 1877, to September, 1880, average 4.77 inches; Nephi, for two years and six months, from March, 1863, to August, 1865: Average 20.55 inches; maximum 25.96 inches, 1864, and minimum 13.72 inches, 1863. Old Camp Floyd, for two years six months, from July, 1858, to December, 1860: Average 7.33 inches; maximum 11.98 inches, 1859, and minimum 4.83 inches, 1860; and Goshen for one year eleven months, from July, 1881, to June, 1883: Average, 4.96 inches.

The mountainous portions consist mainly of Silurian, Carboniferous, Jurassic, and Tertiary, with small patches of Archæan, Trachyte, Rhyolite, and Basalt, the valleys of Quaternary. The Wahsatch here shows Cambrian, Silurian, Devonian, Carboniferous, and Triassic, while the Uintah at the northeast is Upper Carboniferous. King gives for the main body of the Wahsatch about 25,000 feet of intercalated quartzose, mica, and hornblende schists, with quartzites at top (Azoic), with about 3,000 to 4,000 feet (Palæozoic) principally calcareous and dolomitic material, with intercalated beds of quartzite and grits; also limestone and quartzose beds, the balance (Triassic) being lime beds, sandstone capped, Dolomite (1,800 feet), siliceous limestone, and Quartzite. Most of the ranges are mineral-bearing, ore beds occurring persistently in the limestone.

The following list contains districts that have been worked:

No.	Name of district.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north.		
			° ′	° ′		
1	American Fork	G. M. Wheeler	111 33	40 21	Wahsatch Range	Progress Rep., 1872, p. 14.
2	Little Cottonwood	do	111 43	40 35	do	Progress Rep., 1872, p. 15.
3	Big Cottonwood	do	111 35	40 38	do	Progress Rep., 1872, p. 16.
4	Howland	do				Not reported.
5	Uintah	do			Wahsatch Range	Not reported.
6	Blue Ledge	do				Not reported.
7	East Tintic	Lieut. Marshall	112 10	39 55	East Tintic Range	Progress Rep., 1872, p. 17.
8	West Mountain	G. K. Gilbert	112 10	40 30	Oquirrh Range	Progress Rep., 1872, p. 18.
9	Camp Floyd	do	112 10	40 20	do	Progress Rep., 1872, p. 19.
10	Ophir	do	112 15	40 22	do	Do.
11	Mount Nebo	F. Klett	111 45	39 40	Wahsatch Range	Progress Rep., 1872, p. 23.
12	Salt Marsh	H. Granger				Not reported.
13	Pinto	Lieut. Dinwiddie	113 28	37 36	Same as Iron City	Progress Rep., 1872, p. 24.

Routes.—The Utah Southern Railroad traverses northerly and southerly, emerging near Holden, and proceeding thence to Frisco, 280 miles. The Utah Western connects Stockton with Salt Lake. Branch roads are; from West Jordan for Bingham Cañon; Sandy for Alta; Lehi for Tintic; and at American Fork for the cañon of same name, celebrated for its alpine scenery; another branch at Nephi connects with Fountain Green and Wales. At Provo the Denver, Rio Grande and Western Railroad runs to Scofield, in East Valley, en route to Denver. The old overland stage road (along which runs the Western Union Telegraph) traverses the sheet latitudinally, and the Salt Lake and Saint George road longitudinally. The lines of the the Deseret Telegraph connect almost every settlement with Salt Lake.*

SHEET 52 D (SOUTHEAST QUARTER OF SHEET 52).

Locality.—Part of central Colorado.

Scale.—One inch = 4 miles or 1 : 253440. Area, 4,229 square miles. Boundaries, 39° and 39° 50′ north latitude and 105° 30′ and 105° 52′ 30″ longitude west from Greenwich. Adjacent published sheets: E. 53 C, SE. 62 A. and C., S. 61, SE. 61 A. Surveyed during 1873, 1876, and 1879.

GENERAL PHYSICAL FEATURES.

The area is pre-eminently mountainous, the principal uplifts being parts of the Saguache and Snowy Ranges, constituting our true "Sierra Madre."

The remaining portions are the "South Park," a mountain-inclosed basin, and the narrow valleys of the Arkansas and minor streams. The Continental Divide traverses the sheet in a northerly and southerly direction, entering at 105° 53′ at the north, and emerging at 106° 36′ west longitude. It is pierced by a number of passes, but otherwise its outline is bold, tortuous, and rugged, impracticable of approach by ordinary communication.

The subordinate divides are mountain ridges falling away with the drainage east and west. East of the main divide the waters drain to the Gulf, while to the west they drain to the Pacific.

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*The total population (1880) was 59,670, or approximating 3.6 to the square mile. All except, say, 2,000, are found east of a line passing from the southern end of Salt Lake to the emergence of the Saint George Road. The largest town was Provo (3,264). There were (1880) seventy-four post-offices. The area under cultivation (1880) was 142,379 acres. The principal productions are wheat, barley, oats, Indian corn, Irish potatoes; also fruit and grapes.

The lowest level is about 8,000 feet, while the highest, as Lincoln and Gray peaks, exceeds 14,000 feet. The whole western portion is one grand mountain mass, from which has been carved, by glaciation and other means, cañons, gulches, and narrow isolated valleys, beds of the present streams. The picturesque little valleys and glades of the segment of South Park embraced, warrant the name "Park," which is a misnomer as applied to the whole expanse, which is an undulating detrital plateau.* The climate of this area is exceptionally severe in winter, while for summer it is such that cultivation of the ordinary cereals and vegetables is impracticable, except for warm exposures at lowest levels. The resources are almost entirely of a mineral and grazing character, the most important development of the former having been in and around Leadville. Here the principal ore deposits occur in Blue Limestone (Lower Carboniferous) and, in connection with the overlying porphyry, often at the contact. The ores are mainly chloride of silver, carbonate of lead, and Argentiferous Galena, surrounded by silica and clay, and accompanied by oxides. The exploitation of these limestone and porphyry beds, which cover a wide area, has been principally near the California Gulch, where first discovered. It is unsafe to predict the future of an intelligent and scientific prospecting and development of the ore bodies, the index to which is the outcropping porphyry.

The following are among the Silver Mining Districts of the area:

No.	Name of district.	By whom visited.	Approximate geographical position.		Remarks.
			Long. west.	Lat. north.	
			° ′	° ′	Feet.
1	Nevada	O. Loew	105 31	39 46	7,000
2	Griffith	O. Loew and J. J. Stevenson	105 41	39 42	8,500
3	Union	Dr. Kampf	105 40	39 45	8,000
4	Snake River	Professor Stevenson	105 50	39 36	8,000
5	Montana	do	105 39	39 45	8,000
6	Upper Union	do	105 40	39 43	8,000
7	Idaho	do	105 32	39 43	7,000
8	Morris	do	105 46	39 42	7,500
9	Montgomery	do	106 06	39 43	10,000
10	Buckskin	do	106 10	39 20	10,000

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* There are a number of mountain ranges, which include thirty-seven principal peaks (seventeen at least above 10,000 feet). There are seven prominent passes.

Timber abounds in many localities, partially sufficient for home consumption, but grazing, especially in South Park and the valley of the Arkansas, predominates. Larger game, as elk and deer, are found, especially in the western parts, and an abundance of fish, more particularly in streams flowing toward the Colorado.

LAND CLASSIFICATION.

There has been determined 2.1 per cent. tillable land (approx.) 13.24 per cent. grazing, 66.68 per cent. timber, and 17.98 per cent. arid or barren, the latter principally above the timber line on mountain slopes and summits. The area within which a search for precious minerals is likely to be rewarded is a large percentage of the whole, representing, it is believed, one of the largest and most permanent mining centers in Colorado.

The Hayden Survey gives for the Saguache a body of Metamorphic Granite, with exposures of Upper and Lower Carboniferous, Eruptive Granite, and Rhyolite, Moraines and Placer Bars, with Metamorphic Granite predominating for the Park Range, and beds of Silurian, Upper and Lower Carboniferous, Triassic, Cretaceous, and Rhyolite, also Placers, with Metamorphic Granite in preponderance, elsewhere, with beds similar to the above, and placers, especially in the Blue River drainage.

Emmons[*] distinguishes the Mosquito Range, in which the Leadville mines occur, as having been uplifted after the Cretaceous, and hence, geologically, not a part of the Park Range. The sedimentary beds in which the Porphyry was intruded were deposited in Paleozoic and Mesozoic times.[†]

The Archæan consists of Granites and Crystalline Schists, upon which rests a lower Quartzite (Cambrian), about 200 feet thick, then a white lime (Silurian) about 200 feet, then usually a white Porphyry, the blue limestone, then white and other Porphyrys, with Weber Grits superimposed, making about 4,000 feet for the Carboniferous; on the flanks are lake and recent beds. The structure is the most complex near Leadville, becoming a simple monoclinal near Buffalo Peaks Slight exposures of Diorite, Porphyrite, and Rhyolite occur in contiguous areas. It is not at all impossible that valuable ore concentrations will be discovered at horizons below the blue limestone in connection with the white limestone and quartzite, and until the Archæan Granites and Schists are reached.*

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[*] See Monograph XII, U. S. Geological Survey. Geology and Mining Industry of Leadville.—Emmons.

[†] Prof. J. J. Stevenson defines the present Rocky Mountain System as having resulted, especially, from four marked upheavals, occurring as follows: First, at close of Carboniferous; second, at close of the Trias; third, at close of the Cretaceous; fourth, during the Tertiary. The first and third upheavals were the most general. (See Vol. III, U. S. Geog. Surv. Reps., p. 501.)

Routes.—The Pueblo and Arkansas Valley Railroad enters near 106° 15′ longitude west, joining the South Park division of the Union Pacific Railroad at Como. From Dillon it passes via Ten Mile Creek hence to Leadville, and Granite further south (Sheet 61). The Eagle River Branch joins at Leadville, running north via Tennessee Pass toward Eagle River The Denver and South Park Railroad, starting from Denver (5,197 feet), following the South Platte to South Park, enters the area near 39° 23′ north latitude, connects at Como with the Blue River Branch, thence running southward to Garo, where a branch connects via Fairplay with Alma, and thence southwest, emerging near 105° 56′ longitude west southerly to Buena Vista (Sheet 61). Its total length in 1884 was 379 miles.†

SHEET 53 C.

Locality.—Part of central Colorado.

Scale.—One inch = 4 miles, or 1 : 253440. Area, 4,228 square miles. Boundaries, 39° and 39° 50′ north latitude and 104° 7′ 30″ and 105° 30′ longitude west. Adjacent published sheets: S. 62 A, SW. 61, W. 52 D. Surveyed during 1873 and 1876. Embraces southeast quarter of No. 53.‡

GENERAL PHYSICAL FEATURES.

The territory embraced lies entirely east of the Great Continental Divide, and within the Mississippi drainage. The western rim of the Great

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* The rain-fall for Georgetown is given by the Signal Service for one year and nine months, from October, 1878, to August, 1887, at an average of 13.62 inches.

† The total population (1880) was about 45,662, or approximating 11 per square mile. The sheet embraces Lake County, the greater portions of Gilpin, Chaffee, and Gunnison Counties. The principal towns are Leadville (14,820), Georgetown (3,550), Breckenridge (3,005), Central (2,626), Silver Plume (1,800), Fairplay (500), and Red Cliff (500), all in 1880. There were (1880) seventy-one post-offices.

‡ The principal cities and towns are Denver, Golden, Black Hawk, Box Elder, Franklin, Castle Rock, and Huntsville.

Plains and the foot-hills of the Main, Snowy or Front Range, with the Kenosha, through which the Platte debouches into its own local valley, constitute the main features, which are varied by narrow valleys towards the mountains and along certain drainage lines. The divides are all subordinate, being mountain ridges between streams in the western, and rolling hills between drainage lines, in the eastern part of the sheet.*

The following summary of observations between November, 1871, and July, 1883, taken from the means of the signal office at Denver, serve to give some idea of the measured elements of climate for this latitude: Mean annual temperature, 49.1° Fahr.; mean relative humidity, 48; average precipitation, 14.55 inches; prevailing winds, south; highest temperature (105° Fahr.) occurred in August, 1878, and the lowest (−29° Fahr.) in January, 1875; the greatest precipitation occurs during May.†

The resources are good, especially the agricultural, along the Platte Valley. The eastern half is principally utilized for grazing, but mining for the precious metals is considerably prosecuted along the western foothills.

Commerce centers at Denver, where manufactures will ultimately follow; while the food production is, in the main, sufficient for home consumption, leaving a surplus, from mining and stock raising, that may be exchanged for articles of convenience, comfort, and luxury.

The area of 1,590.86 square miles of the western portion of this atlas sheet has been examined with the following result: 8.5 per cent. arable, 57 per cent. pasturage, 30 per cent. timber, and 4.5 per cent. arid. The average of grazing would be largely increased by including the balance.

The Central and Queen mining districts belong to the area, both near together (7,000 feet) in Clear Creek Basin. The Hayden Survey has determined for the mountain part of this area a body of Metamorphic Rocks, overlaid at exposures with upper Carboniferous and Triassic, with Cretaceous, Tertiary, and Post Tertiary for the "Plains," with beds of Basalt and Trachyte. In and about Manitou Park the Archæan is superposed by Silurian, Lower Carboniferous, and Triassic. Alluvium is confined to narrow valley strips. The distribution of the Metamorphic, Paleozoic (Silurian and Carboniferous), Mesozoic (Triassic, Jurassic, and Cretaceous), Tertiary and Eruptive Rocks, for the greater part of Sheets 52 D, 53 C, 61 and 62, as determined by Prof. J. J. Stevenson, will be found in Vol. III, U. S. Geographical Survey Reports, pp. 343–425.

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* The mountainous portion aggregates 1,280, the valley 138, and the plains 2,810 square miles Seventeen prominent peaks may be noted, six above 10,000 feet.

† The Signal Service gives the rain-fall at Denver for eighteen years one month, between December, 1869, and December, 1887, at an average of 14.46 inches; maximum 20.27 inches, 1875, and minimum 11.14 inches, 1873, and for Golden, for five years, between May, 1860, and August, 1887, at an average of 18.43 inches. (See also Annual Reports 1874 and 1877, and Vols. III and V).

Routes.—The Kansas Pacific Railroad, entering near Byers, proceeds westward to Denver, whence radiated (1884) the Denver and South Park, Colorado and Cheyenne Division of the Union Pacific, Denver and Rio Grande, Denver and New Orleans, the Colorado Central, and Denver and Boulder Railroads.*

SHEETS 56 B and D.

Locality.—Parts of central and eastern California and western Nevada.

Scale.—One inch = 4 miles or 1 : 253440. Area, 8,604 square miles. Boundaries, 37° 20′ and 39° north latiude and 119° 15′ to 120° 37′ 30″ longitude west of Greenwich. Adjacent published sheets: N. 47 D, NE. 48 C, E. 57, and SE. 65. Surveyed during 1876, 1877, 1878, and 1879.

GENERAL PHYSICAL FEATURES.

The area belongs principally to the drainage of the Sacramento, with the exception of a narrow strip along the eastern and north central border of 56 B, which appertains to the Great Basin. The main orographic features consist of parts of the main Sierra Nevada and its foot-hills, from Merced River on the south to the southern end of Lake Tahoe at the north. The balance consists of that part of the Great Valley of California bordering on these foot-hills as above. The arable land is mostly confined to the valleys.

The divide between the Great Basin and the Sacramento (the Sierra Summit) enters 56 B near 119° 51′ longitude west and emerges at 119° 36′

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* The total population (1880) was 46,263, or approximating 11 per square mile. The whole of Douglas and Jefferson Counties is included except a little of the latter, also parts of Gilpin, Clear Creek, Park, El Paso, Elbert, and Arapahoe counties. The principal towns (1880) are Denver (35,630), Golden, (2,916), Black Hawk (2,005). With the exception of Monument (255), on the Denver and Rio Grande Railroad, all others were less than 200 each.

longitude west, traversing 56 D near the northeast corner. The main passes of the Sierra are four and all difficult. (See list of passes, p. 123 *et seq.*)

The subordinate divides are the ridges of the mountain flanks and foot-hills separating the drainage areas. The principal drainage lines are parts of the Merced, Tuolumne, Stanislaus, Mokelumne, Cosumnes, American, Carson, and Walker Rivers.

The principal ranges are parts of the Sierra Nevada, the Pine Nut, and Sweetwater.

There are sixty-five named and measured peaks, from a total of one hundred and forty-eight mountain summits, each over 10,000 feet in altitude. Each of the streams traverses cañon walls for a part of its course, that of the Yosemite, through which the Merced runs, being the most prominent. (See Yosemite Sheet.)

The following mining districts are noted:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	′	°	′		
1	Alpine	A. R. Conkling	119	46	38	45	Eastern Sierras, silver	Annual Report, 1878.
2	West Walker River	do	119	20	38	45	Pine Nut Range, silver	Do.
3	Confidence	do	120	00	38	10	South Fork Stanislaus, silver	Do.
4	Monitor	do	119	40	38	42	6069, Sierras, silver	Do.
5	Silver Mountain	do	119	43	38	38	6500, Sierras, silver	Do.
6	Placerville	do	120	47	38	43	Foot-hills of Sierras, gold	Do.
7	Washington	do	120	30	38	11	do	Do.

The main body of the Central Sierras is Granite (Archæan), interspersed with columnar and other masses of Trachyte and Basalt, with unaltered Tertiary and Cretaceous Sandstones and Limestones (marine) at the base of the foot-hills (composed of metamorphic slates and granite), with a belt of gold-bearing ores in Metamorphic Slates, often accompanied by metamorphosed sandstones traversing the lower foot-hills, longitudinally, the entire length of the sheets.

Gold-bearing veins are found in the Granite, but more especially in the Slates. The prominent hydraulic workings have been found in heavy deposits of detrital material, stratified and nearly horizontal, underneath lava, and over the granites and slates. These beds vary, but are chiefly fine-grained sandstone, interstratified with fine argillaceous shales and clays, with gravelly beds, called "cement," exactly such as would be found in an ordinary river bed, below which is the "paygravel" or the "channel." These are old river beds covered, in the post-tertiary, by volcanic flows from the High Sierra. The ordinary post-tertiary placer beds or surface washings have here been pretty much exhausted. The Mariposa estate consists of belts of highly metamorphic sandstone and slates (Jurassic), interspersed with beds of limestone, with bands of serpentine, also steatite and talcose slate. Very little volcanic accumulation and no great hydraulic works exist in Mariposa County. There is a belt of big trees (a species of redwood (?) of limited range) extending from Tulare to Calaveras County, at elevations from 5,000 to 7,000 feet. One of the most noted groves is at Calaveras, the base rock of which is granite, overlaid with volcanic masses. Professor Whitney measured a trunk 23 feet in diameter, and determined for it the age of one thousand three hundred years. Copper and Hematite iron are found in Calaveras County. Lower Tertiary Sandstones in Amador County contain Lignite. The auriferous belt is 30 miles wide (Triassic) in El Dorado County, the slates predominating. The formations exposed other than Archæan are Jurassic, Triassic, Cretaceous, Tertiary, and Volcanic. The intimate geologic relations of this great mountain region are yet but partially determined, the State Geological Survey of California not having completed its work.[*]

Routes.—There is now a railroad nearly to the Yosemite, otherwise wagon roads built at the call of the mining development are the only means of communication. Here many irrigation reservoirs can be located. The evidences of ancient Glaciers from 1,000 to 2,000 feet in thickness are found in the high Sierras of this region.[†]

SHEET 57.

Locality.—Parts of southern Nevada and eastern California.

Scale.—One inch = 8 miles or 1 : 506880. Area, 17,209 square miles. Population (1880) approximating 11,404. Boundaries, 37° 20′ and 39°

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[*] The Signal Service gives for Placerville, near western edge of 56 B, for ten years and four months, between January, 1874, and May, 1886, an average rain-fall of 39.04, with a seasonal maximum of 61.81 inches, 1875–'76, and minimum of 22.67 inches, 1876–'77.

[†] For further descriptions see Annual Reports 1877, 1878, and 1879, and Vol. VI.

north latitude and 116° 30′ and 119° 15′ longitude west from Greenwich. Adjacent published sheets, N. 48, NE. 49, E. 58, SE. 66, S. 65, W. 56 (B and D) NW. 47 (A, B, and D). Surveyed in 1871.*

GENERAL PHYSICAL FEATURES.

Except for a very small area at the southwest corner, the whole belongs to the Great Basin, prominent subordinate parts of which are Walker and Mono Lake basins, with parts of Owen's River and other separated interior basins. The Sierra Nevada summits are found at the southwest corner of the sheet, while exemplars of the Basin Range Systems constitute the mountain portion of the balance. These have mostly meridional axes, rising from and surrounding high detrital valleys and level desert wastes. The water-shed between the Great Basin and the Sacramento is found at the southwest, while all other divides merely separate the Walker from the Owen's River Basins and from other small sub-basins of the interior, which hold the scant supply of water remaining to these regions.

The southeast portion is substantially a desert waste, while the water supply available for the northwest and western parts is insufficient for agriculture.

The mountain ranges and groups, partly outliers of the Eastern Sierra (joined with a master grasp to this immense chain), of which there are not less than eleven (with fifteen principal peaks, four above 10,000 feet), are mineral bearing, with scarcely an exception, and have been prospected and exploited at many points, many of which have been abandoned on account of the supposed paucity of ore as well as difficulty of access, but which in many instances lie dormant only again to be wrought upon as communications advance and mining becomes fixed. The intricate contours of the profusion of mountain forms show everywhere sub-aerial denudation. There are four prominent lakes, four principal passes, and three cañons. Nothing but the mining industry can ever be of any great importance in this area of not less than 17,000 square miles. Where irrigation would admit of large production in many valley-bottoms, water can not be had and the summer rain-fall is nearly nothing. With scarcely an exception, the valleys are the beds of old lakes, the beaches of many of which are still outlined against the mountain flanks. While reference has been made to the great desert of southwest Nevada, it should be stated that the application of the word "desert" to any portion of the earth's surface is arbitrary and not warranted by a systematic nomenclature. It is often applied to large expanses, which, as compared with other more fertile regions of like extent, might be characterized as desert. The idea that the "Great American Desert," so called, embraced the greater part of the Western Mountain Region, between the Rocky Mountain and Pacific Coast Ranges has been gradually exploded, since more accurate and detailed surveys have pointed the many practical resources that nature affords. Many of the valleys are without grass, but with artemisia persistent, with soil sandy and gravelly, occasionally rocky, with often plenty of good water at springs, and with mountain ridges marking the horizon in every direction. The mountain ranges are clad with a few scattering scrubby trees, mostly nut pine.

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* No part of the area represented by this sheet is published except at scale: 1 inch = 8 miles. All existing editions are out of print.

The principal towns are Aurora, Benton, Belmont, Columbus, Bishop Creek, and Ellsworth.

No.	Name.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north,		
			° ′	° ′		
1	Twin River	G. K. Gilbert	117 17	38 50	Toyabe Range	Prog. Rep., 1871, p. 41.
2	Jefferson	do	116 55	38 37	Toquima Range	Do.
3	Manhattan	do	117 00	38 30	do	Do.
4	Mt. Chief	Several	116 50	38 57	do	Do.
5	Silver Bend	G. K. Gilbert	116 55	38 36	do	Do.
6	San Antonio	Dr. Hoffman	117 20	38 20	San Antonio Mountains	Prog. Rep., 1871, p. 45.
7	Montezuma	do	117 15	37 47	Near Carroll Peak	Prog. Rep., 1871, p. 46.
8	Alida	do	117 14	37 43		Prog. Rep., 1871, p. 47.
9	Gold Mountain	do	117 25	37 21	Extension of Silver Pk. Rge.	Do.
10	Palmetto	do	117 37	37 31	Silver Peak Range	Do.
11	Green Mountain	do	117 40	37 21	do	Do.
12	Columbus	do	118 05	38 10	do	Prog. Rep., 1871, p. 48.
13	Silver Pk. and Red Mt	Lieut. Lyle	117 42	37 46	do	Do.
			117 46	37 52	do	Prog. Rep., 1871, p. 53.
14	Blind Spring	Dr. Hoffman	118 20	37 55	Also Dr. Loew, 1875	Prog. Rep., 1871, p. 46.
15	Oneota	do	118 30	37 45		Prog. Rep., 1871, p. 49.
16	Montgomery	do	118 20	37 50	White Mountains	Do.
17	Deep Spring Valley	F. Klett	118 03	37 27	do	Prog. Rep., 1871, p. 49.
18	Union	Lieut. Birnie	117 35	38 53	6,700, Near Bald Peak	An. Rep., 1877, p. 1269.
19	Mammoth	do	117 44	38 57	6,800, near Paradise Peak	Do.
20	Lodi	do	117 53	38 59	5,300, near Lodi Peak	An. Rep., 1877, p. 1279.
21	Bodie	A. R. Conkling	118 59	38 12	Near Braley Peak	An. Rep., 1878, p. 80.
22	Castle Peak	do	119 14	38 05	Near Castle Peak	An. Rep., 1878, p. 84.

These several districts have been worked with varying degrees of success for some and failure for others.

Beds of borax, sulphur, alum, etc., are noted.

The backbone of the Sierra is Granite. South of Mono Lake is a chain of extinct volcanoes of trachytic and other volcanic rocks, with obsidian and pumice abundant, and another volcanic range about 25 miles eastward, while volcanic formations predominate between the heads of the Walker and Owen's Rivers. The table of lava nearly crosses the valley at Bishop Creek. (Whitney, Geol. Surv. of Cala.)

The balance of the sheet is composed of the usual Basin Range mountains.[*]

Routes.—The Carson and Colorado Railroad, built since this area was surveyed, traverses the whole sheet from north to south, reaching Carson Lake, continuing thence to Hawthorn Station, Soda Springs, and Owen's River Valleys to terminus at Hawley. Its northern terminus is Mound House on Virginia and Truckee Railroad (atlas sheet 47). Stage routes connect Hawthorn with Aurora, Bodie, and Bridgeport; also Candelaria with Silver Peak and Montezuma. Big Smoky Valley is traversed by a good wagon road.[†]

SHEET 58.

Locality.—Part of eastern and southern Nevada and southern Utah.

Scale.—One inch = 8 miles or 1 : 506880. Area, 17,208 square miles. Boundaries, 37° 20′ and 39° north latitude and 113° 45′ and 116° 30′ longitude west from Greenwich. Adjacent published sheets: N. 49, NE. 50, E. 59, SE. 67, E. 66, SW. 65, W. 57, NW. 48. Field work during 1869, 1871, and 1872.[‡]

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[*] The "Basin Ranges" or "Range System" of mountains are described by Mr. G. K. Gilbert as composed of: First, sedimentaries; second, granite and allied rocks (nuclei of ranges or dikes), and, third, volcanic. They are mostly simple and compound monoclinals, parallel, of moderate dimensions, and with some regularity of upheaval, the forces, being usually simple vertical uplifts from loci below the earth's crust, were uniform over large areas. The valleys are intervals between lines of greatest uplift. Clarence King gives a stratigraphical summary, designating the rocks of the several formations for a section along the fortieth parallel, on p. 544, Vol. I, of his reports. A description of Black Lake, near Benton, and analysis of its waters, is found on page 191, Annual Report of 1876. For further description see Progress Report, 1871, Annual Report 1876–77, and Vol. V.

[†] Towns and population: Bodie, Cal., 6,000 (mining); Candelaria, 9 miles west of Columbus, 1,200 (mining); Grantsville, 13 miles southeast of Ellsworth, 475, and Belmont, 869.

[‡] No quarter sheets have been published. All existing editions are out of print.

PRINCIPAL PHYSICAL FEATURES.

The area belongs to the Great Basin. The mountainous portion consists entirely of nearly meridional ranges (nineteen in number) of the Basin systems, surrounding elevated detrital valleys, mostly without permanent drainage lines, each in turn a minor reservoir for the scanty precipitation. At the southeast certain small valleys are susceptible of cultivation. The valleys are detrital without exception, often presenting broad expanses of sandy waste in the southwest portion, Pahranagat and Meadow Valleys affording most in cultivation. The divides are ridges of the mountains that form the perimeters of all the areas of subordinate elevation, constituting a number of small inclosed basins of the Great Interior. The drainage lines are few and insignificant.*

The low divides between the detrital valleys admit of easy transit northerly and southerly, whereas east and west routes must often deviate to effect mountain passages.

The following mining districts had been opened:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Lat. north.		Long. west.			
			°	′	°	′		
1	Shoshone	G. M. Wheeler	114	10	38	48	Snake Range	Progress Report, 1869, p. 6.
2	Patterson	do	114	45	38	35	6,500, Schell Creek Range.	Progress Report, 1869, p. 12.
3	Ely	do	114	50	37	55	5,900, Ely Range	Progress Report, 1869, p. 14; 1872, p. 42.
4	Tim-pah-ute	do	115	40	37	30	Tim-pah-Ute Range	Progress Report, 1869, p. 23.
5	Pahranagat Lake.	do	115	15	37	36	Pahranagat Range	Progress Report, 1871, p. 43.
6	Reveille	do	116	05	38	00	Reveille Range	Progress Report, 1869, p. 67; 1871, p. 42.
7	Hot Creek	do	116	20	38	30	Hot Creek Range	Progress Report, 1869, p. 68.
8	Morey	do	116	12	38	38	7,380, Hot Creek Range	Do.
9	Grant	do	115	25	38	30	9,000, Grant Range	
10	Rattlesnake	do	116	30	38	30	Hot Creek Range	Progress Report, 1871, p. 38.
11	Tybee	do	116	22	38	30	do	Progress Report, 1871, p. 40.
12	Freiburg	do	115	30	37	54	Near Worthington Peak	Progress Report, 1871, p. 42.
13	Highland	do	114	31	37	58	6,000, Highland Range	Progress Report, 1871, p. 43.
14	Blind Mountain	do	114	40	38	05	Ely Range	Do.
15	Groom	G. K. Gilbert	115	40	37	25	7,000, Tim-pah-Ute Range	Progress Report, 1871, p. 44.
16	Bristol	E. E. Howell	114	40	38	05	Ely Range	Progress Report, 1872, p. 37.

The resources are largely mineral, mostly undeveloped and difficult of access. The Pioche mines have been the greatest producers. However, new mining centers are being discovered, and better transportation, together with improved mining resources, will lead to a thorough examination of this and all the western mountain region for permanent areas within which the search for the precious metals can be continued indefinitely.

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* There are nineteen main peaks (each above 10,000 feet), four lakes, and five cañons.

The Snake, Schell Creek, and Highland Ranges are Carboniferous and Silurian, as also the Ely, with an area of Rhyolite on its eastern slope. There are large rhyolite exposures at the southeast, while all the valleys geologically noted are Quaternary.[*]

The climate is typical of the Great Basin south of the fortieth parallel, of which that for Salt Lake and Carson are representative points. At no point has the actual determination of the annual rain-fall been made, except at Pioche, where the annual average from July, 1877, to June, 1883, inclusive, was 6.75 inches (greatest in December), with a mean annual temperature for the same period of 49.8° Fahr. and 38.5 for relative humidity, with maximum temperature of 98° Fahr. in July, 1878, and minimum of —13° Fahr. in December, 1879, with south as prevailing wind.[†]

Routes.—Pioche and Bullionville Railroad. Mines to reduction works, length 13 miles. The main route is that from Eureka and Hamilton (Sheet 49), via Pioche, Panacca, and Clover Valley to Saint George, Utah (Sheet 67), marked by a telegraph line.

Latitudinally through the northeast quarter runs a wagon road built westward from Utah in 1857 by the Mormons. The meridional boundary line between Utah and Nevada runs near the eastern border of the sheet. The (approximate) population (1880) was 2,000, or .11 to the square mile. Post-offices, eleven.[‡]

SHEET 59.

Locality.—Southeastern Utah.

Scale—One inch = 8 miles or 1 : 506880. Area, 17,208 square miles. Boundaries, 37° 20′ to 39° north latitude and 111° to 113° 45′ longitude west from Greenwich. Adjacent published sheets: N. 50, S. 67, SW. 66, W. 58, N. W. 49. Field work during 1872 and 1873.[*]

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[*] No special land classification observations were made. For further description see Progress Reports, 1869, 1871, and 1872, and Vol. V.

[†] The Signal Service gives the rain-fall for Pioche for five years ten months, between August, 1877, and May, 1883, at an average of 6.47 inches, with maximum of 8.36 inches, 1878, and 4.67 inches, 1880.

[‡] The principal settlements are Hyko, Patterson, Pioche, and (Mormon) Panacca, Clover, Round, Rose and Eagle Valleys, and Homer.

PRINCIPAL PHYSICAL FEATURES.

The whole area, except a small southeasterly corner, belongs to the Great Basin, and especially to the minor drainage of the Sevier. It consists of two distinct types, *i. e.*, the Basin Range and Colorado Plateau systems, of orographic features. The line of division, forming part of the Great Basin perimeter, marked by sharp plateaus edges, begins in the northeast corner and emerges at the southwest at latitude 37° 30′ north. The former has the usual display of serrated ridges, inclosing detrital valleys, while the latter is constituted of the contorted and eroded plateau forms of the newer formations, presenting contours that defy description. The major part of the area is mountain and plateau with valleys, wide in the interior and narrow in the plateau region. The western portion is desiccated; the central consists of rich and productive soils, valuable through irrigation, but the easterly third (land of the cañon and plateau) is of but little value except for its coal. The Great Basin part was covered in the early Quaternary by Old Lake Bonneville, beaches of which are traceable, the whole being desiccated and practically worthless for agriculture. The main divide is a portion of the southeast perimeter of the Great Interior Basin, separating the former from the exterior drainage of the Colorado.[†]

The main river (Sevier) rises fan-shaped in many sources in the plateau, traversing finally valleys of varying width and character, hence through portions of the range systems, passing into reservoir in the northwest corner of Sheet 50. The change from the range to the plateau system is plainly indicated by the topographic reliefs and often abruptly, so that profiles are an index of the practically passable ridges of the central, and those impracticable in the southeastern portions, about the Dirty Devil and Escalante Rivers. Most marked are the differences between the broad and long valleys, such as the Escalante and Preuss, and the narrow strips fringing running streams of the plateau, which latter may be termed cañon valleys. In the days of Bonneville and Frémont the Wahsatch was considered to extend indefinitely southward toward the Colorado. The distinct ranges into which this great system is divided are for the first time delineated upon this sheet and its neighbor, No. 50. The elevations of the Great Basin portion are from 4,600 to 11,894 feet.

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[*] Published only at the scale 1 inch = 8 miles. Existing editions out of print. Principal towns are the Mormon settlements of Fillmore, Beaver, Parowan, Cedar City, etc., along the narrow strip west of the Wahsatch.

[†] There are eight principal ranges and five mountain groups, five plateaus and two mesas, two passes, and several cañons, seven lakes, and eleven principal peaks (eight above 10,000 feet).

The climate is typical of the Great Basin south of the fortieth parallel. (See astronomical observations at Beaver.)*

The developed resources are principally agriculture and stock raising by the Mormons; but mining has been conducted in a desultory fashion, having hitherto been almost prohibited by the Mormon policy, and always open to improvement and development, while great areas of timber centrally located yet wait local markets.†

The mountain ridges consist (geologically) of Archæan, Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, and Tertiary, interspersed with Trachyte and Rhyolite beds, as well as large masses. The plateaux are Tertiary, Cretaceous, and Triassic, as well as Trachyte and Rhyolite. The valleys of the interior are Quaternary, while those of the Colorado Cañon region are eroded from the Jurassic.‡

The following silver-mining districts were visited:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	′	°	′		
1	Silver Belt	Lieut. Marshall	113	26	37	40	Iron Mountains	1872, p. 18.
2	North Star	G. K. Gilbert	113	07	38	20	East of Picacho Mountains	1872, p. 20.
3	Star	do	113	08	38	25	do	1872, p. 21.
4	Rocky	do	113	02	38	20	East of San Francisco Sp	Do.
5	Lincoln	do	112	55	38	16	Mineral Range	Do.
6	Granite	do	112	48	38	20	do	1872, p. 22, and vol. 2, p. 20.
7	Grand Gulch	do						Not reported.
8	Ohio	F. Klett	112	17	38	22	Beaver Range	1872, p. 22.
9	Iron Spring	do	113	22	37	45	Iron Mountains	1872, p. 23.
10	Beaver League	G. K. Gilbert	113	00	38	33	East of Beaver Creek Range	1872, p. 24.
11	Iron City	F. Klett	113	28	37	36	6,000, Iron Mountains	Do.
12	San Francisco	do	113	15	38	20	West of Paria Cañon	1871, p. 27.
13	East of Monroe		113	05	38	40	Sevier Range	Not visited.

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* The Signal Service gives the following rain-falls: Fillmore, for three years two months, between August, 1877, and September, 1880: average, 30.90 inches; maximum, 65.70 inches, 1878, and 6.62 inches, 1879. Frisco, for two years six months, from July, 18-5, to December, 1887: average, 7.79 inches; maximum, 8.08 inches, 1886, and 7.10 inches, 1887.

† No systematic land classification has been published.

‡ For distribution of volcanic rocks see Part I, Chap. V, Vol. III, p. 118.

The index to the precious-metal ores, here as elsewhere, in the Great Basin at least, is the presence of volcanic beds other than Trachytes and Basalts, and fruitful lines of search are often at their junction with the sedimentary rocks. Hence to some extent the field will ultimately be limited by observation to the true mineral centers and none other. The iron mines are found in Jurassic and Triassic rocks overlaid with Rhyolite.

Routes.—The Utah Southern (see Sheet 50) enters at sink of Beaver Creek, thence via Milford, thence westerly to Frisco. A wagon road follows the Sevier. The Pioche and Salt Lake road traverses at the northwest. The Deseret telegraph line traverses the entire sheet. The southeast Basin rim is nearly everywhere impracticable for routes southward.*

SHEET 61.

Locality.—Central and southwestern Colorado.

Scale.—One inch = equals 8 miles or 1 : 506880. Area, 17,208 square miles. Boundaries, 37° 20′ and 39° north latitude and 105° 30′ and 108° 15′ longitude west from Greenwich. Adjacent published sheets: NE. 53 C, E. 62 A and C, SE. 70 A and C, S. 69. Field work during 1873, 1874, 1875, 1876, and 1877.†

PRINCIPAL PHYSICAL FEATURES.

The area embraced pertains to three independent drainage basins, *i. e.*, the Colorado, Arkansas, and Rio Grande, the source of the latter being in Sheet 61 C.

The Continental Divide (here principally defined by the summit of the Saguache) traverses the entire area in a tortuous northerly and southerly line, appearing on sheets 61 B, C, and D. The ridges forming this divide are here mother mountain masses (Archæan), resting on crystalline and schistose beds, often exposed, and form with their northward continuation a part of the main backbone of the continent. Falling away toward the Pacific and the Gulf drainage are mountain ranges of varying proportions, all elaborate in detail and making one of the most intricate as well as interesting areas.

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* The most populous town is Beaver (1,732 in 1880). Two miles east of Beaver is situated Fort Cameron, the only military post in southern Utah. The total population in 1880, confined to a narrow longitudinal strip, was 17,660, or approximating 1 per square mile. There were (1880) fifty-one post-offices, and 36,537 acres under cultivation. The principal field products are wheat, barley, oats, hay, Indian corn, fruit, and grapes.

† The quarter sheets (61 A, B, C, and D) constitute full Atlas Sheet 61, not otherwise published. Portion of the quarter sheet representing the San Juan mining region has been published on the scale 1 inch = 8 miles. A model of this area in plaster, artistically executed, with vertical scale three times enlarged, was exhibited at the Centennial; afterward deposited in the National Museum, where it is now on permanent exhibition, and also a duplicate furnished the U. S. Military Academy at West Point. The principal settlements are Gunnison, Montrose, Uncompaghre, Centreville, Lake City, Animas Fork, Ouray, Animas City, Silverton, Del Norte, and Saguache.

Other than the Continental or principal divide are those between the Arkansas and Rio Grande and the confluents of the Grand River Fork of the Colorado of the West. The whole region except the San Luis Valley is mountainous, with varied geologic exposures, including a number of suites of the older volcanic rocks, rising to elevations exceeding 14,000 feet. Uncompaghre Peak is next in elevation to Fisherman's Peak, or Mount Whitney, the highest measured peak within the United States.*

The Rio Grande is the main river. This area has a mountain and valley climate, differing materially. The usual wet and dry seasons are here varied, for the high altitudes are not so distinctly marked and correspond to winter and summer respectively.† The winters of the valleys, as compared with those of the mountains habitable for mining, are much less severe, more uniform, and safe for wintering of stock. Stock must be driven from the higher to the lower levels in winter, miners and those who supply them only remaining at the high altitudes above 10,000 feet.

The railroads have made it practicable to supply a large mining population, which has steadily increased since 1873, when parties of the Survey first positively announced the discovery of placer gold on the San Miguel

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* Of the total area of 4,278 square miles for 61 A, 1,804 are mountainous, 1,604 plateau, and 870 valley; of 61 B., 2,600 square miles are mountainous, 428 plateau, 440 valley, and 550 plains; for 61 C, there are 3,345 square miles mountainous, 861 plateau, and 120 valley; while 61 D has 1,443 square miles mountainous, 721 plateau, 1,353 valley, and 810 desert. There are two hundred and fifty-nine principal peaks (observed and named—two hundred and three above 10,000 feet), six lakes, ten passes, and four cañons. There are three main ranges, twelve mountain groups, together with subordinate orographic forms, also plateaus and mesas.

† The Signal Service gives the following rain-falls: Summit, for three years seven months, between August, 1876, and October, 1880: average, 30.67 inches. Montrose, for two years eleven months, between February, 1885, and December, 1887: average, 10.10 inches; maximum, 10.94 inches, 1885, and minimum, 9.64 inches, 1887. Hermosa, for six years eleven months, between April, 1875, and August, 1882: average, 14.66 inches; maximum, 15.54 inches, 1880, and 13.98 inches, 1887.

Creek, since which time, for this territory of several thousand square miles without an inhabitant save the Indian, there has grown up a healthy mining population of not less than 20,000 souls.

The resources are confined (except for the San Luis Valley, susceptible of cultivation) to mining and cattle raising. The waters of the Rio Grande, if diverted for irrigation, are susceptible of reclaiming tens of thousands of acres. Here reservoirs may be made to perform an important function. The area within which mineral concentrations may probably be found is a large percentage, while grazing is everywhere abundant along the rolling foot-hills, the cañons, and minor valleys and numerous glades found at intervals throughout the entire mountainous portions. The native resources for the whole area aggregate (approximately) the following percentages: Arable, 6.62 per cent.; grazing, 28.21 per cent.; timber, 44.27 per cent.; and arid, 20.9 per cent.

The maps of the Hayden Survey give geological exposures from the Archæan to the Quaternary, the former consisting of metamorphic, eruptive, and other granites, and the latter principally of lake and scattered drift, with Alluvium. For 61 A, the West Elk Mountains are Cretaceous at the base, overlaid with beds of Trachyte, Trachyte-Breccia, and Porphyry-Trachyte. The Uncompaghre Plateau is Cretaceous, and the Quaternary is confined to the narrow valley of the Gunnison. There are exposures also of metamorphic granite, Jura-Trias, Tertiary, and Basalt. For 61 B, the Sangre de Cristo are of metamorphic and other granite, superposed by Silurian, Lower, Middle, and Upper Carboniferous, with beds of Trachyte, of which also the Cochetopa Hills are composed, while the Elk Mountains consist of Metamorphic and Eruptive Granite, Silurian, Lower, Middle, and Upper Carboniferous, Jura-Trias, and Porphyry-Trachyte. There are noted also Cretaceous, Rhyolite, and Andesite rocks, with Quaternary (Alluvium, Drift, and Moraines). For 61 C, the San Juan Ranges are metamorphosed Granite and Paleozoic, Devonian, Middle and Upper Carboniferous, Jura-Trias, Cretaceous, Trachyte, Porphyry-Trachyte, Basalt, and Quaternary (Lake Drift). The Uncompaghre Peak is Trachyte. For 61 D, there is Trachyte for the mountains on both sides of the Rio Grande, and Quaternary for the San Luis Valley. There are exposures also of metamorphic and other granite, Lower and Upper Carboniferous, Tertiary, Trachyte-Breccia, and Quaternary.*

Until the removal of the Uncompaghre Utes, after the loss of their famous chief, Ouray, the agency for this branch of the great Ute tribe was at Los Piños, north of the town of Ouray. The reservation has since been surrendered, the Indians moved to Utah, and the land thrown open to settlement by special act.

Routes.—The main line of the Denver and Rio Grande Railroad enters with the Arkansas, which it follows to the junction of the South Arkansas, whence it continues to Leadville, while the Utah division passes southward, crossing the Continental Divide via Marshall's Pass and hence to Gunnison. From Gunnison westward (61 A) it reaches the Uncompaghre at Montrose, hence again to the Gunnison, and turning westward emerges from the area.

The Denver and South Park Railroad connects at Buena Vista with Garo and Fairplay (Sheet 52 D).

The Denver, South Park and Pacific connects Northrop with Quartz Creek. The San Luis branch of the Denver and Rio Grande Railroad extends from Salida, at mouth of South Arkansas, southward via Poncho Pass to the San Luis Valley to its southern terminus at Hot Springs. There are two other branches. Twenty-four miles west of Fort Garland, at Alamosa, the railroad extends to Conejos and Durango (Sheet 69), whence a branch follows the Animas to Silverton. The Crested Butte branch connects Gunnison with the coal district on the Upper Ohio Creek. The total length of the Denver and Rio Grande Railroad in 1884 was 1,685 miles.†

SHEETS 62 A, C, and D.

Locality—Parts of central and southern Colorado.

Scale.—One inch = 4 miles or 1: 253440. Boundaries, 37° 20′ and

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* The Creston and El Dorado mining districts are found mentioned on page 1252, Annual Report 1877, and the mines of San Juan in various reports.

† The population was (1880) 23,603, or 1.37 per square mile. The counties are all of Hinsdale, San Juan, Ouray, Rio Grande, and Saguache, nearly all of Gunnison and Chaffee, parts of Park, Fremont, Custer, Costilla, Conejos, La Plata, Dolores, Miguel, Montrose, and Delta. The largest town is Lake City (1,950). There were (1880) one hundred and thirty-two post-offices.

39° north latitude and 104° 7′ 30″ and 103° 30′ longitude west from Greenwich. Adjacent published sheets: N. 53 C, S. 71 A, SW. 69 B, W. 61, NW. 52 D. Field work during 1873, 1874, 1875, 1876, and 1877.*

PRINCIPAL PHYSICAL FEATURES.

The combined area includes various mountain ridges forming the western limit of the Great Plains, including the mass of which Pike's Peak is the summit, and ranges dividing the Arkansas from the Rio Grande. The western rim of the Great Plains constitutes the eastern portion, while the Great San Luis Valley is reached at the southwest.

The principal divide is that between the Arkansas and Rio Grande drainages, marked by the summits of the Sangre de Cristo and Culebra Ranges and the Cerro Blanco and La Veta Mountains. The main drainage line is the Arkansas.

There five main mountain groups, together with bluffs, buttes, and hills. The whole of 62 D forms a portion of the western rim of the Great Plains and is of plateau form.† Here again is the marked line between the climate of the valleys and the mountains, the latter being comparatively mild in winter, agreeable and cool in summer, except in the more arid portions of the Arkansas.

The following serve to indicate elements of climate for this area:

(1) Fort Lyon, Colo., from January, 1871, to June, 1883: Mean annual temperature, 51.3° Fahr.; average rain-fall, 11.90 inches; highest temperature 105° Fahr., in June, 1881, and the lowest, —25° Fahr., in January, 1883.

(2) Pike's Peak, from November, 1873, to July, 1883: Mean annual temperature 19.3° Fahr.; average precipitation, 32.81 inches; prevailing

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* These sheets together comprise all except the northeastern quarter of full Atlas Sheet 62. The principal towns are Colorado Springs, Pueblo, Cañon City, Huerfano, and Las Animas. The military posts of Forts Garland and Lyon are found in Atlas Sheets 62 C and D, respectively.

† Of the 4,278 square miles of 62 A, 1,283 are mountainous, 214 plateau, 214 valley, and 2,567 belonging to the western border of the Plains; while for 62 C, 1,273 square miles are mountainous, 508 valley, and 2,545 belonging to the Plains out of a total of 4,228 square miles. There are fifty-nine principal peaks (thirty-two above 10,000 feet), two lakes, nine passes, and five cañons.

wind southwest; highest temperature 64° Fahr., in July, 1879, and lowest —37° in January, 1875, and December, 1878.

(3) Fort Garland, Colo., from January, 1871, to June, 1883: Mean annual temperature, 41.2° Fahr., average annual precipitation, 14.74 inches; greatest precipitation in July; highest temperature 91° Fahr. in 1881, lowest, —30° Fahr., in November, 1880.*

The first is typical of the western border of the Plains, the second of the high mountains, and the third of the Rio Grande at these latitudes. The natural resources admit of a moderate amount of farming along the narrow beds of the streams, expanding somewhat eastwardly on the Arkansas, together with mining at numerous points throughout the mountain ridges, and grazing almost everywhere along the flanks of the mountains, even to near the beds of the streams.

Timber is found along the foot-hills, reaching even to and beyond 11,000 feet.

The native resource classification of 62 A and C is as follows: Arable, 5.67 per cent.; grazing, 66.74 per cent.; timber, 22.36 per cent., and arid or barren, 5.23 per cent.

Irrigation has been but little used. Reservoirs could be availed of to some extent as land becomes more valuable. Attempts have been made at obtaining artesian water near Fort Lyon, but so far without success. Reference to the mining districts at Hardscrabble and Rosita will be found in Annual Report, 1876. The maps of the Hayden Survey give Archæan

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* The following *rain-falls* are taken from the Signal Service publication (Sen. Ex. Doc. 91, 50th Cong., 1st Sess.).

No.	Locality.	Interval.		From—	To—	Annual mean.	Maximum.		Minimum.	
		Yrs.	Mos.			*Inches.*	*Ins.*	*Yrs.*	*Ins.*	*Yrs.*
1	Colorado Springs	7	7	Dec., 1871	Dec., 1887	15.79	20.16	1872	14.55	1886
2	Pike's Peak	14	1	Nov., 1873	Nov., 1887	29.33	45.57	1881	9.28	1884
3	Fountain	2	3	Nov., 1871	Feb., 1875	10.97	......	......	......	......
4	Las Animas or Fort Lyon	19	0	Jan., 1869	Dec., 1887	12.20	16.97	1873	7.67	1871
5	South Pueblo	8	9	Sept., 1872	Aug., 1887	12.67	15.61	1885	11.72	1878
6	Old Fort Massachusetts	5	1	Oct., 1852	July, 1858	17.23	18.81	1856	13.67	1856
7	Fort Garland	21	7	Oct., 1858	Oct., 1883	[illegible]	[illegible]	1872	5.44	1861

masses for the main mountain ridges, and members of the other geologic eras terminating in the later Quaternary.

For 62 A, the Arkansas Valley is Cretaceous (Colorado). Pike's Peak is a mass of Metamorphic Granite, with beds of Trachyte, flanked and fringed at the south by Silurian, Trias, Jura, and Cretaceous rocks.

The exposures around Manitou and the Garden of the Gods are Silurian, Upper Carboniferous, Trias, Jura, and Cretaceous. Wet Mountain Valley is of Metamorphic Granite at its perimeter, and drift centrally.

For 62 C, the Spanish peaks are a body of Upper Carboniferous, flanked by Cretaceous, with fan-shaped, flaring masses of Porphyry-Trachyte at the summits. The Sangre de Cristo Range consists of Metamorphic and other granites and Upper Carboniferous, with outlying exposures of Cretaceous and Trachyte, the Quaternary being drift lake beds and Alluvium. The Wet Mountains, with a base of Metamorphic Granite, show also Trias, Jura, and Cretaceous, with Trachyte beds.

For 62 D, there is shown Cretaceous, Post-Cretaceous, and Alluvium (narrow). Professor Stevenson refers the lignite-bearing series of southern Colorado to the Upper Cretaceous, which, as measured at Cañon City, consists of:

(1) Sandstones, varying in color and structure, and including thin beds of lignite, 250 feet.

(2) Shales, sandstones, and lignites, 175 feet.

(3) Sandstone and shale, the former containing thin beds of lignite, 350 feet.

Routes.—The Denver and Rio Grande and the Denver and New Orleans Railroads (see 53 C) traverse the area southerly, the former via Pueblo to Trinidad (70 A), emerging near Apishpah. At Colorado Springs a branch runs to Manitou, famous for its climate and springs. At Pueblo the Atchison, Topeka and Santa Fe Railroad arrives from the East, while the Denver and Rio Grande Railroad traverses the Arkansas en route to Cañon City. Another branch leaves the main stem at Cucharas en route westward to Fort Garland, where it joins other branches leading to Del Norte (61 D) and farther south (69). The grade of the line across La Veta Pass and the Sangre de Cristo averages 128 feet to the mile.

The Denver and New Orleans Railroad, after leaving Easton (53 C), follows substantially the old stage road to Pueblo.*

SHEET 65.

Locality.—Eastern California and southern Nevada.

Scale.—One inch = 8 miles or 1 : 506880. Area, 17,588 square miles. Boundaries, 35° 40′ and 37° 20′ north latitude and 116° 30′ and 119° 15′ longitude west from Greenwich. Adjacent published sheets: N. 57, NE 58, E. 66, S. 73 A. and C, NW. 56 B and D. Field work during 1871 and 1875.†

GENERAL PHYSICAL FEATURES.

The crest of the Sierra Nevada, with Fisherman's Peak, or Mount Whitney, nearly central, traverses almost north and south the western half of the sheet, marking the water-shed between the Great Basin and that of the Sacramento.

The basin ranges occupy the whole eastern half. More than half is mountainous, the balance consisting of alluvial and detrital valleys and desert-like plains.‡ The contrast between the considerable downfall of the whole region west of the Sierra summits and the sterile region eastward is most marked, this crest-line being the frame-work, so to speak, of the desert land of the interior.

The principal divide is that between the Great Basin and the Sacramento, crossing which there are no natural passes, the only known line of transit being a rough trail from Lone Pine to Visalia, passing south of Fisherman's Peak, or Mount Whitney. The main drainage lines are the Tulare and Owen's Rivers. In the southwest quarter of the sheet, bordering Tulare Lake and River, is land susceptible of easy cultivation through irrigation, while directly eastward (latitude 36° north) is found a series of desert valleys culminating in Death Valley, so called, the beds of which are either of shifting sand or saline and alkaline efflorescences, mostly destitute of vegetation and entirely unfit for cultivation. The anatomy of the Sierra is now quite well known, while the several interior ranges belong to the Basin system, the groups of ridges forming the frame-work of independent, undrained areas, where streams, containing water sufficient to sustain a feeble existence, lose themselves in the valley depression or disappear before emerging from the lateral cañons of the foot-hills.

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* The sheets embrace all of Huerfano County, and Pueblo County except a small strip at the east; El Paso County almost entire; a small portion of Park County; about one-half of Fremont County, two-thirds of Custer, and a small part of Costilla. The whole population (1880) was 31,963, or approximately 3.70 per square mile. The largest town is Pueblo (7,221 in 1880). There were (1880) sixty-one post-offices. See also Prog. Rep., 1871, and Annual Report, 1876.

† The full sheet is out of print. The quarter sheet embraces the southeastern portion. The principal settlements are Lone Pine, Independence, Cerro Gordo, and Swansea. The military post (Camp Independence) has been abandoned.

‡ Sheet 65 D has 1,768 square miles of mountainous, 442 of plateau, 884 of valley, and 1,326 of desert territory. Total, 4,420 square miles.

The most sterile of all the local desert tracts are Death Valley, Amargosa, and the waste northward therefrom. In 1871 the trails and sources of water supply within these particular and contiguous tracts were but little known. The Great Death Valley itself was considered an almost impassable obstacle, dangerous alike for man and beast. Our operations have developed the existence of hitherto unknown creeks and springs, making it possible in future to transit this country along selected lines with comparative ease, when proper precautions are taken. No where else is the transition from the coastwise territory to the Great Basin more marked than in this particular sheet. The high Sierra is the condensing limit for the greater share of the moisture of the lower-air strata, the bulk of which is precipitated before arriving at these crests and thus returns to the Pacific, while the eastward currents traverse the Great Interior robbed of their moisture, hence the resultant rain-fall here is a minimum. This result is enhanced by the fact that the minor ridges of the Sierra extending westward reach high altitudes and cover a wide expanse This portion of the Great Basin is entirely cut off from the humid-laden currents extending inland, axially following the Columbia and portions of the Snake Rivers, the course of which mark substantially the northern limit of the Interior Desert tract, the southern limit of which is only reached where the Colorado joins the Gulf.

At Camp Independence from October 6 to 25, 1875, the precipitation was 0, the maximum temperature 89° Fahr., and the minimum temperature 39° Fahr., with prevailing winds northwest.[*]

The summary at Visalia, Cal., a point near the western border, and typical for the southern part of the Great California Valley, from July, 1877, to July, 1883, gives a mean annual temperature of 61.2° Fahr.; average annual precipitation, 9.12 inches, with prevailing winds northwest; greatest precipitation in February; highest temperature, 109° Fahr. in June, 1879, and lowest, 18° Fahr. in January, 1882.[†]

Quarter-sheet 65 D contains, approximately, 15 per cent. tillable land, 48.2 per cent. pasturage, 9.7 per cent. timber, with 40.6 per cent. barren ground (see L. C. Table). The amount of arable territory is small, that for grazing large. Much of the rain-fall of the Western Sierras passes underground, to be held in artesian reservoirs. Conduits from these are being successfully utilized through artesian wells, now considerably used in irrigation. The agricultural conquest of the Great Valley of California can be made more or less complete by skillfully applying all known means of irrigation by gravitation. A detailed topographic and geologic study should always precede any work of magnitude. Owen's River receives small streams from the Sierra. Near the debouches, in many instances, will be found sites favorable for future irrigation reservoirs.

The profile of the Sierra due west from Owen's Valley is the steepest within our territory, exceeding an average of 1,000 feet per mile. The main body of the Sierra Nevada is Archæan Granite, occasionally lava capped, with bands of sandstones and metamorphic slates. The Granite comes to the edge of the Lava near Fish Springs. About the crests are noted lateral, medial, and terminal moraines of extensive extinct glaciers, especially at the heads of Kings and Kern Rivers. East of Owen's River, slates and limestones overlie granite. The Coso Mountains are of Granite and Gneiss. A great mass of Basalt flanks the entire southern rim of Termination Valley.

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[*] The Signal Service gives the rain-fall at Camp Independence for ten years eleven months, from November, 1866, to August, 1877: average 5.97 inches; maximum 7.06 inches, 1873–74, and minimum 1.63 inches, 1872–73 (*), and for Visalia for eight years one month, from January, 1878, to May, 1886: average 9.25 inches; maximum 13.10 inches, and minimum 3.95 inches, 1878–79. (*) [*Seasonal rainfall from September to August inclusive.]

[†] There are twelve ranges, three mountain groups, with the Table and Black Lava Hills; and among seventy-one principal peaks seventeen are above 10,000 feet. There are two lakes, seven passes, and thirteen cañons.

The Amargosa Range consists of Schists and Sandstones, overlaid by limestone. The Owen's Mountains are composed of Granite-gneiss, and other crystalline rocks. The basin ranges have exposures of the Silurian and Carboniferous, frequently interspersed with both old and new volcanic rock

The mining districts below mentioned had been discovered, properties located, and more or less development made:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	′	°	′		
1	Wancova	G. M. Wheeler	117	55	37	00	Inyo Range	Pub. Rep., 1871, p. 45.
2	Fish Spring	Lieutenant Lyle	118	16	37	03	Near Soldier's Cañon	Pub. Rep., 1871, p. 50.
3	Kearsarge	G. M. Wheeler	118	10	36	50	West of Independence	Do.
4	San Carlos	do	118	00	36	45	Inyo Range	Do.
5	Lone Pine	do	118	03	36	35	East of Fisherman's Peak	Do.
6	Granite Mountain	Lieutenant Lyle	117	42	36	12	Coso Mountains	Pub. Rep., 1871, p. 51.
7	Telescope	Several	117	05	36	18	Telescope Range	Pub. Rep., 1871, p. 52.
8	Lyons	G. M. Wheeler	117	12	36	35	Panamint Range	Do.
9	Death Valley	do	117	07	36	33	Telescope Range	Do.
10	Amargosa	A. R. Marvine	116	30	35	45	Slate Range	Do.
11	Rose Spring	Lieutenant Birnie	117	19	36	16	4,600 feet, Telescope Range	An. Rep., 1876, p. 65.
12	Lookout	do	117	28	36	14	4,290, Argus Range	An. Rep., 1876, p. 67.
13	Coso	do	117	48	36	20	5,600, Coso Mountains	An. Rep., 1876, p. 56.
14	Sumner	D. A. Joy	118	30	35	45	Sierra Nevada	An. Rep., 1876, p. 65.
15	New Coso	Dr. Loew	117	48	36	20	5,600, Coso Mountains	An. Rep., 1876, p. 56.
16	Panamint	do	117	07	36	07	6,000, Telescope Range	An. Rep., 1876, p. 48.
17	Cerro Gordo	do	117	49	36	32	8,200, Cerro Gordo Mountains	An. Rep., 1876, p. 62.

Dr. Loew found the water of Owen's Lake to contain 2.5 per cent. of carbonate of soda and other salts, tasting strongly alkaline and salty, and scarcely fit for medicinal purposes. By diverting the small incoming stream and allowing the lake water to evaporate a great quantity of carbonate of soda could be obtained, which some day may prove an article of commerce. Black and Mono Lakes are similar.*

Routes.—The Southern Pacific Railroad enters the area in the southwest corner at about 36° north latitude, leaving it 5 miles east of the southwest corner. The Carson and Colorado Railroad (see Sheet 57) extends to Hawley, south of Bishop Creek; total length 301 miles.* Various wagon roads may be seen on the map.†

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* See Annual Report, pp. 192-197 for Thermal and Mineral Springs, etc.

SHEET 66.

Locality.—Parts of eastern California, southeastern Nevada, northwestern Arizona, and southwestern Utah.

Scale.—One inch = 8 miles, or 1 : 506880. Area, 17,588 square miles. Boundaries, 35° 40′ and 37° 20′ north latitude, and 113° 45′ and 116° 30′ longitude west from Greenwich. Adjacent published sheets, N. 58, NE. 59, E. 67, SE. 75, SW. 74 B, W. 65, NW. 57.‡

Field work during 1869, 1872, and 1873.

GENERAL PHYSICAL FEATURES.

This area embraces exemplars of the Basin Range systems and of the border land between them and the Great Colorado Plateau, and combines many varieties of mountain and plateau forms of which the territory is largely composed; detrital valleys and desert wastes constituting the balance. The divide between the Great Basin and the Colorado crosses the sheet centrally almost northerly and southerly, forming a part of the southeastern perimeter of the land-locked area. The Colorado is the main drainage line, into which empties the Virgin River.

The sinks, for the little remaining basin drainage, are either reservoir lakes or subterranean.

With the exception of the arable land of the Muddy, Santa Clara Creek, Pahranagat and Pah-rimp Valleys, and Las Vegas Springs, this section is typical of the desest in all its worst phases.

Certain ranges—as Spring Mountain, Kingston, Vegas, Colorado, Meadow Valley, Pahranagat, Belted, and Virgin—are still covered with timber at the summits, and a spring is infrequently noted. Otherwise even the springs found at wide intervals throughout this large area are unreliable, often dry, and many that were found active when visited are not necessarily permanent. The same applies, substantially, to Atlas Sheets 57 and 65. The mouth of the Grand Cañon is found at the southeast, where commences the Colorado Plateau, marking a new character of uplift and displacement, as compared with the basin ranges. This area forms a part of the great Death Valley of southern Nevada, which has lost many of its terrors since the expeditions of 1869, 1871, 1872, and 1875.* Although typical of the Desert, this region is now entered as well as circumvallated by advancing emigration, crossed by the iron river of commerce, and although uninviting to a degree, yet nevertheless has, particularly in the forest and the mine, large store-houses yet to be needed by increasing population, while each decade it grows nearer to centers of settlement. The climate is that of the more southerly parts of the Great Basin; *i. e.*, uniform and mild in winter; parching hot in summer. It may be assumed that within the lower levels of certain desert sections of this sheet, as was observed in the Death Valley depression, the thermometer at midnight in August reaches as high as 119° Fahr.

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* In June, 1883, the prospective terminus was a point near the thirty-fifth parallel on the Colorado River.

† The total population (1880) was 8,068, approximately, or .45 per square mile. Kernville (384) was the largest settlement. The military post of Camp Independence has been abandoned. In Inyo County (1880) there were two hundred and forty-two farms, with 28,323 acres cultivated. Number of post-offices, twenty-seven.

‡ This sheet was not otherwise published than at 1 inch = 8 miles. Existing editions out of print.

The permanent agricultural resources are slight, the grazing considerable, the timber limited, while there is a large field within which to discover and exploit the precious metals.

Geologic notes along the eastern part of the sheet and the cañons of the Colorado show exposures of Archæan, Silurian, Carboniferous, Triassic, Trachyte, Rhyolite, and Basalt for the mountain and plateau structure, and Quaternary for the valleys and desert wastes.

The following mining districts had been located and somewhat developed in 1869, 1871, and 1872:†

No	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	'	°	'		
1	Colorado	G. M. Wheeler and Dr. Loew.	114	45	35	44	1,000 feet	Pub. Rep., 1869, p. 30, and An. Rep., 1876, p. 61.
2	Yellow Pine	G. M. Wheeler	115	25	36	00	7,000 feet	Pub. Rep., 1871, p. 52.
3	Timber Mountain	do	115	45	36	25	Spring Mountain Range	Pub. Rep., 1869, p. 21. Pub. Rep., 1871, p. 53.
4	Cedar	do	114	30	37	15	Mormon Range	Pub. Rep., 1871, p. 42.
5	South Eastern	F. R. Simonton	115	30	37	07	Desert Range	Pub. Rep., 1871, p. 45.
6	Clarke	G. M. Wheeler	115	25	35	00	Spring Mountain Range	Pub. Rep., 1871, p. 53.

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*There are eleven principal ranges, with thirteen prominent peaks; also Arrow Cañon and Meadow Valley Mountains and the Colorado Pleateau, together with three passes and eight cañons.

†Districts in Long Valley and east of the Grand Wash were also visited. See Prog. Rep., 1872.

Dr. Loew remarks that bitter and brackish waters are characteristic of these desert tracts; such as the Virgin River, which is highly charged with bitter-tasting, purgative salts (principally sulphate of soda and magnesia). Analysis does not show, however, any poisonous constituents, but proves that the desert alkaline and salty efflorescences charge these waters.

Routes.—Various wagon routes, including the old California and Salt Lake emigrant road, will be found delineated.

The arable lands of the Muddy Valley aggregate approximately 25,000 acres, of which three-fifths are under cultivation. The old site of Callville marks the farthest point to which steam navigation on the Colorado has been carried.*

SHEET 67.

Locality.—Parts of northern and northwestern Arizona and southern Utah.

Scale.—One inch = equals 8 miles or 1: 506880. Area, 17,588 square miles. Boundaries, 35° 40′ and 37° 20′ north latitude, and 111° and 113° 45′ longitude west from Greenwich. Adjacent published sheets; N. 59, SE. 76, S. 75, SW. 75, W. 66, NW. 58 Field work during 1871, 1872, 1873.†

GENERAL PHYSICAL FEATURES.

The whole area is a part of the Great Colorado Plateau, most pronounced in its type, and through which the Colorado River flows, always in a cañon of greater or less proportions. The subærial and subaqueous cutting of this region have produced orographic types without counterparts, so far as known, in any other quarter of the globe. The divides are all between tributaries of the Colorado and the mother stream. The Colorado Chiquito is the only important line of drainage other than the main river, which traverses the entire extent covered by the sheet, which embraces the heart of the Grand Cañon. This extensive plateau region is the resultant of a great uplift over an area of fully 120,000 square miles more or less uniform in areal pressures, as compared with the usual dynamic disturbances along axial lines, common to the western mountain region.

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*The entire population (1880) did not exceed 1,000 persons, principally Mormons. There were seven post-offices.

†Not otherwise published than on the inch to eight-mile scale. Edition out of print.

The magnificence of the subærial carving and the thickness of the geologic formations displayed make it a wonderland for all time and a most fruitful school and field for the geologist of the present and the physicist of the future. The minor plateaus have been given local and special names.[*]

No mountain ridges exist. The little valleys, where found, though narrow, are fertile, and offer inducements to settlement. The climate varies from that found at the levels of the streams and the more elevated plateau terraces, between which is a vertical distance, in instances, of 7,000 feet, the former being mild and uniform in winter with agreeable and comparatively cool summers. Grazing is the prime resource, agriculture being of but little avail, while the search for the precious metals is restricted. Coal croppings, however, are abundant in the north and northwest portions. General mention of land classification will be found in the published reports. The entire area affords exposures of sedimentary rocks such as limestones, quartzites, etc., except where immense beds of basalt have obtruded through these beds and lie dispersed over considerable areas. In the Grand Cañon Granite (Archæan) appears at the base of these sedimentary beds. (See Vol. III, p. 162. Fig. 66.)

The plateaus are composed of Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, and Tertiary formations, with obtruded beds of Trachyte, Rhyolite, and Basalt.

The rocks are various sandstones and limestones, with calcareous and arenaceous shales for the mouth of the Grand Cañon. The Tertiary is absent except at the northwest corner of the sheet. All of the great divisions of geologic time are represented in the cañon district of the Colorado.[†]

The Cretaceous is composed of calcareous sandstones and argillaceous and Carboniferous shales, about 2,600 feet thick;[‡] the Jurassic consists of sandstones and gypsiferous shales, also calcareous sandstones and shales (800 to 1,200 feet); the Trias, (2,500 to 3,500 feet) cross-bedded sandstones and saliferous and gypsiferous clays or shales; the Carboniferous (4,000 to 5,000) being mostly thick masses of limestone (Aubrey limestone, 800 to 900 feet; Aubrey sandstone, 1000 feet; Redwall limestone, 1000 feet); the Silurian, or probably primordial, being the Tonto group (marbled limestones, 800 to 1,200 feet; Tonto shale, 600 feet, and Tonto sandstone, 80 feet) with Archæan, made up of Granites and schists at the base of the series.*

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[*] There are five sub-plateaus, also the Red Hurricane Ledge, Aubrey, Skumpah, and Vermillion Cliffs, and White Mesas, and the Sehsavwits Mountains. There are five principal peaks, three passes, and six cañons.

[†] See Gilbert, table on p. 171, vol. III, and remarks pp. 178 *et seq.*

[‡] See Howell, p. 275, vol. III.

It is impracticable to delineate the wonderful convolutions of nature found traced in these cañons, except upon maps of a very large scale. Lateral gorges almost innumerable exist, mostly with dry beds. The climatic conditions of a maximum dryness, irregular and often violent precipitation, and persistent wind storms account for the corrugated superficial face of nature.

The river is constantly deepening, not alone from water erosion, but by the chiseling and grinding force of the minute pebbles and particles of siliceous and other matters driven by the current, which is given a rotatory motion by the winds.

The edges of the sub-plateaus most distant from the river bed are nearly perpendicular, and usually of deep-red sandstone or limestone, with summits covered by a scanty growth of sage and greasewood, interspersed with grass.

Juniper or piñon prevail in the vicinity of volcanic cones, with occasional areas of yellow pine (pinus ponderosa). Grazing, somewhat utilized, is abundant.

Communication is confined to roads and trails (see map). The total population (1880) is 6,151, not including the Scheavwitz Indians, a small nomadic tribe, who live along the narrow cañon valleys, planting small patches of corn, wheat, and watermelons, subsisting in part by the chase and upon roots, mice, etc. There were (1880) twenty-one post-offices. The eastern portions are scarcely settled and poorly known, almost destitute of water and but little marked even by trails.

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* Gilbert gives for section of the Grand Cañon at Diamond Creek, Granites and schists, superposed by the Tonto group, the Redwall limestone, Aubrey sandstone, and the Aubrey limestone (see fig. 39, p. 69, vol. III). In Chap. XII of Monograph II, U. S. Geological Survey, Captain Dutton writes of the History of the Grand Cañon district. He states that prior to the Carboniferous period large bodies of Silurian and Devonian strata were deposited, and that afterwards the region was elevated, greatly eroded, and then submerged. The Carboniferous was deposited uncomformably upon the denuded surfaces from 12,000 to 16,000 feet thick, continuing until the close of the Mesozoic. About 10,000 feet were eroded during the Tertiary. The Colorado River is thought to have been the outlet of a great Eocene lake in the early Tertiary, and to have persisted in its ocean course and connection ever since. The present Grand Cañon is considered as the result of corrasion extending only through the Carboniferous, and somewhat into the Archæan.

The principal precipitation in the Grand Cañon region is in the winter months. There is some rain in November, and slight showers occur over small localities of the high plateaus even in summer, where snow occurs in winter, while at the middle level the downfall (alternating snow and rain) is small and irregular.*

SHEET 69.

Locality.—Parts of southern Colorado and northern New Mexico.

Scale.—One inch = 8 miles, or 1 : 506880. Area, 17,588 square miles. Boundaries, 35° 40′ and 37° 20′ north latitude, and 105° 30′ and 108° 15′ longitude west from Greenwich. Adjacent published sheets: N. 61, NE. 62 A and C, E. 70 A and C, SE. 78 C, S. 77, SW. 76. Field work during 1873, 1874, 1875, and 1877.†

GENERAL PHYSICAL FEATURES.

Quarter-sheets B and D constitute the eastern half of the main sheet 69, which half lies entirely in the Basin of the Rio Grande, except a small area at southeast corner belonging to the Pecos. The northwest quarter belongs to the San Juan drainage. The mingling of ridge, plateau, mesa, and narrow valley forms makes this sheet an individual unlike any other of the series. The Continental Divide follows in much of its course the rolling crests of plateaus, instead of ridges, which plateau areas, when at lower levels, were probably the bed of a cretaceous sea, joining the present Gulf of Mexico with that of California, if not the Pacific proper.

The principal divide is the shed of surface water flowing either to the Gulf of Mexico or California, traversing the sheet nearly northerly and southerly in its central parts for two-thirds of its width, then turning to the westward, emerging at the southeast corner. The main drainage lines are the Rio Grande and San Juan. At the north, the Rio Grande traverses impracticable cañons, its valley narrowing so that cultivatable land upon its banks disappears, except in the proximity of a lateral confluence. This changes at Embuda, whence to the southern border the valleys widen, settlements increase, and the area under cultivation is considerable.* Limited areas are cultivated in the valleys also of the Chama, Jemez, and other creeks, that could be expanded considerably pursuant to a skillful system of irrigation. This area is one of the most interesting of the Southwestern Interior, needing further detailed examination as to its geologic and mineral structure and native resources. The Santa Fe Range, a prominent serrated ridge or cordillera, and its companion, the Las Vegas Range, lie in the southeast corner, while the Jemez and other mountain groups rear their summits above the plateau. The southwest portion is made up of plateaus and mesas. At the north and northwest, and especially north of the San Juan, serrated ridges die away into the plateau region at the south.

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* The Signal Service gives the following rain-falls: Saint George, six years two months, between January, 1861, and October, 1880: Average, 11.57 inches. Harrisburg, two years two months, between February, 1869, and February, 1872: Average 13.14 inches. Mount Carmel, three years four months, between January, 1874, and July, 1878: Average, 36.71 inches; maximum, 58.05 inches, 1874, and minimum, 22.50 inches, 1876. Kanab, five years four months, between May, 1872, and October, 1879: Average, 11.09 inches; maximum, 14.60 inches, 1876, and minimum, 7.37 inches, 1877.

† The principal settlements are Santa Fe (the second oldest settlement in the United States, where military headquarters have for a long time been established), San Ildefonso, Santa Cruz, Abiquiu, Plaza Alcalde, Taos, Costilla, Culebra, and Jemes.

These ridges are Granite-based, overlaid by limestone and other sedimentaries, interspersed with older volcanic masses (eruptive and intrusive), in the vicinity of which precious-metal croppings and ores are found. The climate of the southerly portions consists of wet and dry seasons in the valleys, with medium precipitation, cultivation by irrigation only. Some of the constituents appear in the following means taken from the Signal Office records: Santa Fe, November, 1871, to June, 1883: mean annual temperature, 48° Fahr.; mean relative humidity, 44; average annual precipitation, 14.51 inches; prevailing winds, east; the highest temperature, 97° Fahr. in August, 1878, and the lowest, −13° Fahr. in December, 1879; the greatest precipitation in July. Fort Lewis, June, 1880, to July, 1883: Mean annual temperature, 44.7° Fahr.; average annual rain-fall, 13.49 inches; the highest temperature, 103° Fahr., occurred in August, 1880, and the lowest in January, 1883; the greatest precipitation occurs in August.†

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*Of the 1,750 square miles of 69 B found in Colorado, 437 are mountainous, 219 plateau, 656 valley, and 438 plains; while for the balance, 2,624 square miles in New Mexico, 656 are mountainous, 328 plateau, 984 valley, and 656 plains. For sheet 69 D, 1,560 square miles are mountainous, 1,820 plateau, and 1,040 valley. There are four principal ranges and seven prominent mountain groups, with fifty-two main peaks (twenty-five above 10,000 feet), ten plateaus, seven mesas, six lakes, three passes, and eleven cañons.

†The Signal Service summaries give rain-falls as follows: Santa Fe, thirty years ten months, between February, 1850, and December, 1887: Average, 14.81 inches; maximum, 24.84 inches, 1854, and minimum, 7.75 inches, 1883. Old Fort Lowell, four years six months, between October, 1868, and June, 1874: Average, 11.49 inches; maximum, 13.58 inches, 1872, and minimum, 7.42 inches, 1873. Old Camp Burgwin, five years nine months, between September, 1854, and May, 1860: Average, 8.65 inches; maximum, 14.70 inches, 1859, and minimum, 3.86 inches, 1856.

The resources are: Agricultural for narrow strips, grazing for the greater share, considerable timber at the southeast and northwest, with many mines already opened, and much prospective mineral wealth. In the southeast quarter of Sheet 69 D the sites of early Spanish mines are still recognizable, while this industry at present is confined largely to the San Juan area.

The observed land classification for 16,059 square miles indicate, approximately, 5.8 per cent. tillable, 51.9 per cent. grazing, 36.35 per cent. timber, and 5.95 per cent. absolutely arid or barren, defining substantially a timber and grazing region. The Mexicans have practiced irrigation for long periods. The constituents of the silt borne in suspension by the Rio Grande waters, being rich and fertilizing, produce a mud covering as a result of the irrigation, which completely renovates the soil. This mud is found by analysis to be richer in phosphates than that of the Nile.*

Prof. J. J. Stevenson and others have determined Igneous, Tertiary, Cretaceous, Carboniferous, and Archæan formations for the ridges and higher portions of the eastern part of the sheet, with Quaternary for the valleys proper. Professor Stevenson determined the profile from the Rio Grande to the Canadian Plains (across the Santa Fe Range) as follows, from west to east: Tertiary (Loup Fork); Carboniferous (sandstones, limestones, and shales) over Archæan (reddish and coarse granites, fine-grained gneiss, mica schists, and quartzites), faulted toward Mora Valley; Jura-Trias (thin layers of sandstones and shales); Cretaceous (Dakota = sandstones, limestones, and shales; Colorado = argillaceous limestones, laminated sandstones, and arenaceous shales); Basalt for the Canadian Hills and west of Turkey Mountains.† The Santa Fe Range is substantially Archæan, flanked on either side by heavy Carboniferous beds. The Turkey Mountains are Dakota over Carboniferous, and the Canadian Hills are Basalt, superposed upon Colorado and Dakota beds of the Cretaceous.

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*It has been determined that the most necessary mineral combinations for the best soil are: Sulphuric acid, phosphoric acid, potassa, lime, magnesia, and oxide of iron. Phosphoric acid and potassa are the most valuable, but are least in quantity. These substances impoverish after prolonged cultivation, and must be replaced artificially to insure adequate productive power.

†See Plate 1, opposite p. 406, vol. III, Geology Supplement.

Routes.—The Denver and Rio Grande Railroad enters from the north near the one hundred and sixth meridian, thence to Antonito, where a branch diverges for Silverton, Colo. (Sheet 61.)

From Antonito this railroad follows a southern course, striking the bed of the Rio Grande at Embuda Station, following thence to Espanola, the nearest station to Santa Fe, thence it continues along the Rio Grande, forming a junction with the Atchison, Topeka and Santa Fe Railroad. (See Sheet 77.) Many wagon roads are shown, while Indian trails predominate, especially in the central and western section.[*]

SHEET 70 A and C.

Locality.—Part of southeastern Colorado and northeastern New Mexico.

Scale.—One inch = 4 miles, or 1 : 253440. Area, 8,794 square miles. Boundaries, 35° 40′ and 37° 20′ north latitude, and 104° 7′ 30″ and 105° 30′ longitude west from Greenwich. Adjacent published sheets: N. 62 C, S. 78 A, SW. 77, W. 69, NW. 61. Field work during 1874, 1875, and 1876.[†]

GENERAL PHYSICAL FEATURES.

The main orographic forms are the serrated ridges on the western side of each sheet and beyond the plains proper, together with the western rim of the Great Plains, bordering on the staked plains at the south, and the plateau forms rising above their general level, the whole interspersed with minor cañons and narrow valleys of erosion. The principal divide is that between the tributaries of the Arkansas on the east and those of the Rio Grande at the west.

The main drainage lines are the Purgatory, the Canadian, and Mora Rivers, all tributaries of the Mississippi Basin. The Pecos heads in 70 C.

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[*] The most populous town is Santa Fe, the capital of New Mexico, with 6,635 inhabitants (1880). The total population (1880) was 30,062, or approx. 1.7 per square mile (one of the most thickly settled portions of New Mexico). The military posts are Fort Lewis, on the headwaters of the Rio de la Plata, and at Santa Fe. Post-offices, thirty-eight (1880). There are eight Indian Pueblo villages, each one of which had granted to it by the Spanish Government a tract of land one league square. Most of these grants have been confirmed by the United States. The nineteen pueblo villages (7,879 inhabitants), with 505,657 acres of reservation, had (1880) under cultivation 13,940 acres, raising 10,215 bushels of wheat, having 1,850 houses, 2,236 horses, 6,525 cattle, and 24,400 sheep. The agency for the Southern Utes is at Tierra Amarilla, on the Chama.

[†] These quarter-sheets constitute the western half of principal sheet No. 70.

Heavy mountain ranges, each worthy of special description as to physical features, form the western limit of the Plains.[*]

Climate.—The following is the meteorological summary at Fort Union, N. Mex., from June, 1880, to July, 1883: Mean annual temperature, 49.2° Fahr.; average annual rain-fall, 17.68 inches; the highest temperature, 96° Fahr., occurred in July, 1881, and the lowest, −30° Fahr., in January, 1883; the greatest precipitation occurs in July (compiled from Post Hospital Reports by Signal Service). The resources of this area are but slightly agricultural, irrigation being necessary, largely grazing, with timber throughout the foot-hills and lower levels of the mountain ranges, and mines of the precious metals within the mountains proper. The determined land classification for the whole area is as follows: Arable, 3.67 per cent.; grazing, 47.86 per cent.; timber, 43.96 per cent.; arid or barren, 4.52 per cent.[†] Substantially a grazing and timber section.

The mountain ridges have been determined as Archæan, Carboniferous, Cretaceous, and Igneous, the plains as Cretaceous and Quaternary, often capped where rising into the plateau forms with Basalt. Professor Stevenson gives the geologic profile on the thirty-seventh parallel, from the Rio Grande to the plains across the Culebra Range, from west to east, as follows: Basalt in Rio Grande; Trachyte passing under Basalt and partly covered with conglomerate; Archæan (coarse, gneissoid, and mica granites, compact gneiss, mica schists, and quartzites) at the base, superposed on eastern slope of Culebra by Carboniferous (3,276 feet of sandstones, limestones, and shales),[‡] then Dakota (sandstones), Colorado shales, etc., Laramie (1,800 feet of sandstones and shales) groups of the Cretaceous, the latter capped by Basalt for the Raton Plateau. The generalized section of the Laramie group within the Trinidad coal-fields shows thirty-three separate and distinct beds of lignite, mostly coking coal, of an aggregate thickness exceeding 180 feet.* The Culebra Range is an axis of Archæan, with Trachyte on the west and a wall of Carboniferous on the east. The Raton Plateau is Basalt over Laramie and Colorado groups of the Cretaceous.†

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[*] Of the 1,750 square miles of 70 A lying in Colorado 547 are mountainous, 437 plateau, 438 valley, and 328 plains; the balance of 2,624 square miles in New Mexico has 820 mountainous, 656 plateaus, 656 valley, and 492 plains. The mountain, plateau, valley, and plains area of 70 C are 1,040, 520, 260, and 2,600 square miles, respectively. There are five main ranges, the Turkey Mountains and Canadian Hills, with forty-five peaks, twenty-two above 10,000 feet; also the Canadian and Raton Plateau, three mesas, seven passes, and six cañons.

[†] The Signal Service summarizes rain-fall as follows: Trinidad, Colo., three years six months, between August, 1877, and February, 1881: Average, 21.73 inches; maximum, 33.84 inches, 1878, and minimum, 15.78 inches, 1879. Fort Union, twenty-nine years one month, between September, 1851, and October, 1887: Average, 18.51 inches; maximum, 39.47 inches, 1861, and minimum, 10.38 inches, 1870.

[‡] See pp. 77 and 78, Vol. III, Geology Supplement.

The following mining districts had been opened in 1875 and 1876:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	′	°	′		
1	Moreno, Willow, and Ute Creeks.	Lieut. Birnie..	105	12	36	37	11,000 feet, Cimarron Range, near Baldy Peak.	An. Rep., 1876, p. 66.
2	Aztec..................	A. R. Conkling	105	12	36	38	11,000 feet, Cimarron Range.	Do.
3	Golconda..............	....do.........	105	23	36	40	9,000 feet, Taos Range......	An. Rep., 1876, p. 301.

Mining developments are still subjected to the whim and caprice of this as yet unsettled industry, and change materially from year to year.

Routes.—The Atchison, Topeka and Santa Fe Railroad, entering from Sheet 62 A, reaches Trinidad, and continuing southward it finally reaches Romero en route to Las Vegas (78 A) and onward. At El Moro Station the Denver and Rio Grande Railroad branches to the Trinidad coal-fields.‡

SHEET 73.

Locality.—Southwestern California.

Scale.—One inch = 4 miles, or 1 : 253,440. Area, 17,952 square miles. Boundaries, 34° and 35° 40′ north latitude, and 116° 30′ and 119° 15′ longitude west from Greenwich. Adjacent published sheets: N. 65, NE. 66. Field work during 1871, 1875, 1876, and 1878.§

GENERAL PHYSICAL FEATURES.

The area comprises part of the Great Basin, the southern Sierra Nevada, a number of separate coast ranges, which separate the strip of territory in vicinity of Los Angeles and to the south from the Great Basin, with a part of the Great Valley of California, near Kern Lake, minor coast valleys west of the coast ranges, while more than half the area belongs to the Desert, in which is found, alone, the Mohave River, fringed with vegetation. The main divide is that between the Great Basin (a portion of its southwest perimeter) and the coast drainages, of the Sacramento at the north and other minor streams southward. The mountains and desert claim the greater share of the area, while the arable lands, next the coast at the south, semi-tropical in character, are of most pronounced fertility. The mountains are the several coast ranges trending nearly meridionally, breaking away *en échelon* from the flanks of the mass culminating in Fisherman's Peak, or the southern end of the Sierras proper, joined by the Tehachipi as a principal link, together with several mountain groups distributed over the Great Basin portion.[*]

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* See pp. 104 and 105, vol. III, Geology Supplement.

† See Plate II, opposite p. 406, vol. III, Geology Supplement.

‡ The counties are part of Las Animas, Colorado, and parts of Colfax, Mora, and Costilla, N. Mex. Total population (1880), approximately, 20,604, or 2.33 per square mile. Post-offices, twenty-three (1880).

§ Quarter-sheets A and C constitute the western half of full sheet No. 73.

Climate.—The following is the Signal Service summary for Los Angeles from July, 1877, to July, 1883: Mean annual temperature, 60.4° Fahr.; mean relative humidity, 66.4; average annual precipitation, 14.58 inches; prevailing wind west; the highest temperature, 103.5° Fahr., occurred in June, 1879, and the lowest, 30° Fahr., in December, 1878, December, 1879, and January, 1880. The greatest precipitation occurs in December.[†]

The resources are agricultural for the Los Angeles region, as well as also the lower end of Tulare Valley, especially through irrigation, timber within the foot-hills of the Coast Ranges and the Sierra Nevada, grazing for specified portions of the higher levels, while mining for the precious metals is prosecuted at an ever-increasing number of localities in all the mountain ridges, including those of the desert proper.

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[*] Sheet 73 A has 2,354 square miles mountainous, 557 plateau, 280 valley, and 1,275 desert, while for 73 C there are 3,035 of mountain, 375 of ocean, 610 valley, and 490 desert. On acount of the barrier presented by the coast ranges flanking westward from the southern Sierra Nevada to the ocean, southern California is more isolated from the balance of the State than is Oregon. There are four main ranges, eight mountain groups, the San José Hills, with sixty-eight principal peaks (thirty-eight above 10,000 feet), seven lakes, nine passes, and twenty-four cañons

[†] Dr. Loew reports on the physiological effects of a very hot climate (see Annual Report 1876, p. 328) and deduces 2.6° Fahr., as the hourly cooling effect on the body from drinking 2 liters of water at 70° Fahr., daily, which is the amount that the temperature of the body would be raised if no more water were available for evaporation, which latter takes place principally from the surface of the body and but little through the lungs. Hence it is that the time within which one must succumb from thirst in

From the observed land classification for 73 A and C the following percentages have been determined: Arable, 10.61 per cent.; grazing, 33.35 per cent.; timber, 12.91 per cent.; arid or barren, 21.92 per cent.; chaparral, 18.73 per cent.; water and marsh, .57 per cent.; water, 1.91 per cent.

Prof. Jules Marcou* refers to the mountains south of the Cañada de las Uvas, the "Sierra Madre," assuming them to be "bayonet-shaped faults" displaced from the meridional trend of the Sierra Nevada, which is resumed farther southward. He states that the granite, pegmatite, gneiss, dioritic and metamorphic rocks, forming the principal mass, are of a geologic date anterior to the Paleozoic, while the "counterforts" of sand, sand-stone, and conglomerate found at Cajon Pass and other portions of these masses date from the Post Pliocene or Quaternary. He found serpentinous dioritic rocks to contain silver and copper near their junction with the Granite in San Gabriel Cañon.

Tertiary sandstones with conglomerate are found on the desert side of the Sierra Liebre.

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such a dry, hot climate is quite brief. The following rain-falls summaries by the Signal Service are taken from Sen. Ex. Doc. 91, 50th Cong., 1st Sess.:

No.	Locality.	Interval.		From—	To—	Annual mean.	Maximum.		Minimum.	
		Yrs.	Mos.							
						Inches	*Ins.*	*Yrs.*	*Ins.*	*Yrs.*
1	Caliente	11	2	Sept., 1876	Nov., 1887	10.93	18.15	1883-84†	2.16	1878-79†
2	Tehachipi	10	10	Nov., 1876	Oct., 1887	11.04	18.77	1883-84†	4.75	1878-79†
3	Mojave	10	10	Sept., 1876	Nov., 1887	4.05	9.96	1883-84†	0.00	1882-83†
4	Old Fort Tejon	9	5	Mar., 1855	Aug., 1864	16.80	32.97	1855-56†	11.67	1856-57†
5	Old Camp Cady	2	2	May, 1868	June, 1870	3.22	....	....	....	....
6	San Bernardino	16	0	July, 1870	June, 1886	16.17	37.51	....	8.86	....
7	Colton	11	0	Sept., 1876	Oct., 1887	9.31	23.25	1883-84†	5.43	1882-83†
8	Nordhoff	5	5	Dec., 1881	May, 1887	27.84	....	....	....	....
9	Los Angeles	16	4	Sept., 1871	Dec., 1887	16.63	32.16	1883-84†	3.87	1871-72†
10	Ravenna	8	1	Sept., 1879	Nov., 1887	11.71	37.25	1883-84†	3.83	1882-83†
11	Newhall	11	3	Sept., 1876	Nov., 1887	14.73	42.11	1883-84†	2.84	1876-77†
12	San Fernando	9	6	Sept., 1877	Aug., 1887	15.29	18.01	1877-78†	7.67	1878-79†
13	Cahuenga Valley	4	2	Jan., 1883	Mar., 1887	19.45	30.43	....	0.00	....
14	Spadra	13	0	Sept., 1874	Nov., 1887	12.10	24.50	1883-84†	5.90	1882-83†
15	Santa Monica	8	8	Sept., 1879	Nov., 1887	12.49	17.80	1883-84†	10.22	1879-80†
16	Sumner	13	5	Sept., 1874	Nov., 1887	5.28	9.10	1883-84†	1.41	1876-77†

*See Annual Report, 1876, p. 158 *et seq.*

† Seasonal rain-fall from September to August, inclusive.

He gives the following résumé for the relative ages of the mountain systems of a part of southern California:

I.—Sierra Madre, of the Primordial epoch, or Laconic, anterior to the Silurian.
II.—Coast Range, of the close of the Eocene epoch.
III.—Sierras of San Fernando and Santa Monica, of the close of the Miocene epoch.
IV.—Hills of Los Angeles, of the close of the Pliocene epoch.
V.—Mountains of Cajon Pass (east side of the Sierra Madre) of the close of the Post Pliocene or Quaternary epoch, or, perhaps, even of modern times.

The following districts had been somewhat developed in 1875:

No.	Name.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north.		
			° ′	° ′		
1	El Paso	A. R. Marvine	117 40	35 30	Near El Paso Peak	Prel. Rep., 1871, p. 52.
2	Charlotte	Lieut. Whipple.	118 08	34 29	6,400 feet, near Gleason Peak	An. Rep., 1876, p. 51.
3	San Emidio	D. A. Joy	119 04	34 53	4,800 feet, north of McGill Peak	Do.
4	Green Mountain	do	118 23	35 28	6,000 feet, Pah-Ute Mountains	An. Rep., 1876, p. 52.
5	New El Dorado	do	118 14	35 27	5,000 feet, north of Kelso Valley	An. Rep., 1876, p. 53.

Routes.—The Southern Pacific Railroad enters the area in the northwestern corner, and, traversing the Tehachipi Pass, reaches Mohave Station, from whence the Colorado River division extends eastward. The main stem of this road reaches Los Angeles, also Santa Monica, and south to San Pedro and Santa Ana. From Los Angeles another branch extends via San Gorgonia Pass to Yuma on the Colorado. The Carson and Colorado Railroad (see Sheets 57 and 65) was to have been extended to Mohave Station. Various wagon roads, including a part of the Old Salt Lake road, appear delineated.*

ATLAS SHEET 75.

Locality.—Parts of central and western Arizona.

Scale.—One inch to 8 miles, or 1 : 506880. Boundaries, 34° to 35° 40′ north latitude, and 111° to 113° 45′ longitude west from Greenwich. Area, 17,952 square miles. Adjacent published sheets: NW. 66, N. 67, E. 76, SE. 83.

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* A part of Ventura, Kern, Los Angeles, and Bernardino Counties is embraced. Total population (1880) is 32,733, a trifle less than 2 per square mile. Post-offices, forty-nine (1880).

GENERAL PHYSICAL FEATURES.

This sheet shows, in part, the geographic relations of two great orographic systems (the Colorado Plateaus and the Basin Range), together with the border land between them. The line of separation happens here to be well marked by the topographic distinction of table and ridge, so that part of the southwestern border of the great plateau can be traced by drawing a line from Music Mountain in the northeast toward the southeast corner of the area, passing north of the Black Hills. The area north of this line is part of the great southern bench of the plateau. It is capped by the upper limestone of the Carboniferous, and upon it stand the volcanic peaks called Floyd, Picacho, Bill Williams, Sitgreaves, Kendrick, Agassiz, and Humphreys. The latter four belong to the San Francisco group, which is briefly a series of massive trachytic eruptions, surrounded by small basaltic cones, which have thrown out a great lava mantle extending far to the south and east, covering the somewhat indefinitely named Black Mesa and part of the Mogollon.

To the southwest of the line of demarkation lies the Basin Range country, characteristically broken by a succession of ranges having approximately the same trend, and inclosing trough-like alluvial valleys. The sheet contains four ranges and six groups of mountains, three plateaus and two mesas, one small lake, twenty-four principal peaks (seven above 10,000 feet), two main passes, and four cañons of magnitude.

DIVIDES AND DRAINAGE SYSTEMS.

The entire area, so far as its surface drainage is concerned, belongs to the Colorado Basin. The most important divide is that running from Music Mountain to Floyd's Peak, of the San Francisco Group, and southward over the crest of the Mogollon Mesa, separating the area into a northern and southern water-shed. The waters of the north pass off to the Colorado through the heads of Cataract Creek and the Colorado Chiquito and its tributaries. Those of the south are tributary to Bill Williams Fork on the west and the Gila on the east. The divide of these secondary basins passes from Floyd's Peak over the crest of the Juniper Range, Aztec Pass, Santa Maria, Granite, Weaver, and Date Creek Mountains to the Cactus Plain.

The only stream of importance is the Rio Verde, the drainage of the entire area being confined to small streams and dry arroyos, sometimes filled with water from melting snows gathered in the high plateau.

The highest point in the area (and in Arizona) is Humphrey's Peak in the San Francisco Mountains, 12,562 feet above sea, and the lowest is the Cañon of Bill Williams Fork, about 800 feet above sea.

The lava-capped San Francisco Plateau varies in altitude from 5,526 feet at Lockwood Spring to 6,857 and to 7,108 feet along its most elevated portions, trending to the southeast from the San Francisco Mountains.

The soil immediately adjacent to the lava *in situ* is black and often meager, while that found in the valleys and glades is dark, deep, rich, and of most positive fertility.

Climate.—The prevailing climate is dry, although this section of Arizona is unusually favored as regards rain-fall. The summer climate of the uplands and higher valleys (5,500 feet) is delightful, and the winters mild though variable. The highest peaks of the San Francisco Group carry snow during the winter months, and upon the higher plateaus heavy snows sometimes occur, rarely lying long enough, however, to seriously impede travel. There is a well-marked rainy season during the months of July, August, and September, when showers are frequent. Series of observations at typical points over the whole area are not at hand, but the following meteorological data from the Signal Office records at Forts Verde and Whipple and for Wickenburgh give an idea of what might be expected at similar localities:

At Fort Whipple (altitude 5,340 feet, latitude 34° 33′ north, longitude 112° 28′ west), from November, 1873, to July, 1883, the mean annual temperature was 52° Fahr.; the mean relative humidity 43.2; average precipitation 13.86 inches (maximum in August); prevailing wind south; highest temperature in July (maximum of 103° Fahr., in July, 1878), lowest temperature in January (lowest minimum of —18° Fahr., in December, 1879).

At Fort Verde (latitude 34° 33′, longitude 112° 52′ west, altitude 3,100 feet) from November, 1874, to July, 1883, the mean annual temperature was 60.9° Fahr. (maximum in July, highest 114° in July, 1881—minimum in January, lowest −6° Fahr., in December, 1879, and January, 1882);

the mean relative humidity was 42.4, with an average precipitation of 13.46 inches (greatest in August), with south as the prevailing wind.

At Wickenburgh (latitude 34°, longitude 112° 44′, altitude 1,400 feet) from January, 1874, to April, 1882, the mean annual temperature was 62.9° Fahr., maximum in July, highest 111° Fahr., in July and August, 1877; minimum in January with lowest ± 12°, in 1878); the mean relative humidity was 46.1; the average precipitation 8.6 inches (greatest in August), with south for prevailing wind.*

The Colorado Plateau consists of Silurian, Carboniferous, and Triassic formations, with a large exposure of Basalt.

The ranges in the western and southwestern parts of the sheet are of Archæan, with large Trachyte and Rhyolite areas, while the valleys are all of Quaternary. The Cretaceous and Tertiary of the Plateau series (see sheet 67) are wanting.†

GENERAL ECONOMIC FEATURES.

Timber.—The Mogollon Mesa and the San Francisco Mountains, which have extensive forests, produce the finest timber in this section, the best being the yellow pine (pinus ponderosa), which in large growth clothe the higher altitudes, and Douglass spruce. The lower ranges, as a rule, have a fair growth of full timber; piñon, cedar, or juniper (J. occidentalis), ash, oak, and cottonwood, and sycamore grow in the bottom lands of the principal streams and fringe the glades and openings of the subordinate basins.

Agriculture and Grazing.—Good gramma and bunch grass is to be found throughout the mountains and mountain slopes, affording ranges for large herds of cattle and sheep.

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* The Signal Service gives the following for rain-fall: Old Camp Willow Grove, one year seven months, between February, 1868, and September, 1869: Average 9 inches: Old Camp Hualapais, two years eleven months, between April, 1870, and June, 1873: Average, 20.89 inches. Camp Verde, seventeen years eight months, between December, 1868, and November, 1887; Average, 11.44 inches; maximum, 17.92 inches, 1884, and minimum, 4.60 inches, 1871. Fort Whipple, twenty years seven months, between June, 1865, and December, 1887: Average, 16.83 inches; maximum, 27.13 inches, 1874, and minimum, 10.02 inches, 1880. Old Camp Date Creek, six years three months between May, 1867, and July, 1873: Average, 13.76 inches; maximum 27.84 inches, 1868, and minimum, 13.60 inches, 1870. Wickenburgh, eight years five months, between November, 1875, and January, 1886: average, 9.83 inches; maximum, 17.17 inches, 1884, and minimum, 0.35 inches, 1877.

† For further geologic description see Vol. III, part I, chapter VI; part II, section II, and part III, chapter, IX, section I.

Building material.—Good stone for building purposes may be found in the magnesian limestone of Cañon Diablo, the lava rock of the Mogollon Mesa, and the sandstone in the vicinity of Chino Valley.

The principal agricultural lands occur in Chino and Williamson's Valleys, between the Aztec and Cactus Passes; in the vicinity of Prescott (Fort Whipple) and Fort Verde and in the bottom lands of Bill Williams Fork. South of the San Francisco Mountains along the Prescott and Santa Fe road are little valleys and open glades suitable for farming homes. The deep depression in the southeast corner is the area called the Tonto Basin, containing forest meadows and fine valleys suitable for stock-raising. The soil in the localities mentioned is fertile, and favorable for corn and grain, but as a rule irrigation is necessary to make agriculture here remunerative, as droughts are frequent.

A rough estimate of the classes of lands in this area of 17,952 square miles is: Agricultural with irrigation, 796 square miles, or 4.4 per cent.; grazing, 7,154 square miles, or 39.9 per cent.; timber, 2,614 square miles, or 14.6 per cent.; arid or barren, 7,388 square miles, or 41.1 per cent.

Considerable spaces now covered with a sage-brush growthcan probably never be made productive for lack of water; these notably are the Cactus and Prescott Plains, the flat country in the northwestern part of the area, that north and south of the Cactus Pass, the plains between the Kendrick and Aquarius Ranges, and parts of the basin of Aqua Fria Creek. Of the lands included under the head of agricultural with irrigation probably not over one-fifth is actually under cultivation.

The principal crops grown are barley, Indian corn, potatoes, and some wheat. The ordinary vegetables and fruits can be raised.

Game.—The San Francisco Mountains and Mogollon Mesa include the best game country in this area. In 1871–'73 grizzly, black, and cinnamon bear, deer, and antelope were all noted.

Routes of communication.—The Atlantic and Pacific Railroad crosses the area from east to west; entering at Cañon Diablo, it traverses the forest-clad plateau south of Humphrey's Peak, where it reaches its greatest altitude, 7,355 feet above sea, passes north of Bill Williams Peak and between Mounts Floyd and Picacho, crosses Aubrey Valley, and leaves the area by way of Truxton Springs. From Ash Fork Station on Partridge Creek it is about 50 miles by stage to Prescott.[*]

The main wagon routes to the westward are the Fort Mohave (Colorado River) and Prescott Road and the Ehrenburg (Colorado River) and Prescott Road; to the south the Prescott and Fort McDowell Road; and to the east the Prescott and Apache Road and Verde and Apache Road, and the Old Prescott and Santa Fe Road, striking the Little Colorado at the mouth of Cañon Diablo.

Since this area was surveyed in 1873 the Atlantic and Pacific Railroad has been built, and numerous settlements not shown on the map have sprung up.[†]

A number of mining camps have been established in the Bradshaw or Silver Mountains and the hills east of Prescott, known as the Lynx Creek, Hassyampa, Big Bug, Turkey Creek, Walnut Grove, Pine Grove, Tiger, and Humbug districts. There is also the Weaver district in the range of the same name, the Martinez in the Date Creek Mountains, and the Greenwood in the Aquarius Range and the flat country east of it.[‡]

Wickenburgh, on Hassyampa Creek, and Bradshaw, in the Bradshaw Mountains, are (1880) mining camps of about 200 and 100 inhabitants, respectively. There are other mining settlements in the Bradshaw Mountains. In the Cañon of Beaver Creek, north of Fort Verde, are many interesting ruins of the buildings of extinct aboriginals.

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[*] In 1884 a railroad was in course of construction along this route.

[†] The only town of importance is Prescott, seat of Yavapai County and capital of Arizona; population in 1880, 2,074. Wickenburgh, on the Hassyampa, is a village of about 200. Two miles northeast of Prescott is the post of Fort Whipple, and about 40 miles further east, by road on the Rio Verde, is Fort Verde. According to the census of 1880 the population of this entire area was about 4,800 (or .27 to the square mile), and thus nearly one-half was centered at Prescott and Forts Whipple and Verde.

[‡] The following were post-offices in July, 1883, on the Atlantic and Pacific Railroad: Flagstaff, south of Agassiz Peak, near Antelope Spring; Williams, northeast of Bill Williams Peak, near New Year Spring; Ash Fork, about 50 miles north of Prescott, on north branch of Partridge Creek, and Hackberry, near Truxton Springs. From Ash Fork there is a daily mail to Prescott and Whipple Barracks. Other post-offices are Aqua Fria Valley, Cienega, Stoddard, and Fort Verde, on the Prescott and Verde Road; Big Bug, Bumble Bee, and Gillett, on the Prescott and Phœnix Road; Skull Valley, Antelope Valley, Stanton, and Wickenburgh, on the Prescott and Wickenburgh Road; Cox, Walnut Grove, and Kirby, on the Hassyampa Creek, Simmons, on Mint Creek, Juniper, in Williamson's Valley; Hassyampa, Messville, Bueno, Alexandria, Bradshaw, Walker, Howell, and Tip-Top, in the Bradshaw Mountains. There are also settlements east from the Masatzal Range in the Tonto Basin, at present without direct mail communication. This area embraces the southern and most populous part of Yavapai County and the southeastern part of Mohave County.

No.	Name.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north.		
			° ′	° ′		
1	Maynard	G. M. Wheeler	113 50	35 10	....	Progress Report, 1871, p. 54.
2	Tiger	Lieutenant Lyle	112 15	34 05	Bradshaw Range	Do.
3	Pine Grove	do	112 20	34 10	do	Progress Report, 1871, p. 55.
4	Bradshaw	do	112 20	34 12	do	Do.
5	Turkey Creek	do	112 20	34 18	do	Do.
6	Weaver	do	112 20	34 05	do	Do.
7	Walnut Grove	do	112 22	34 20	do	Do.
8	Hassyampa	do	112 25	34 18	do	Progress Report, 1871, p. 56.
9	Martinez	do	112 00	34 05	Date Creek Mountains	Do.
10	Santa Maria	do	113 00	34 30	Kendrick Mountains	Do.

ATLAS SHEET 76.

Locality.—Parts of eastern Arizona and western New Mexico.

Scale.—One inch to 8 miles or 1 : 506880. Boundaries, 34° to 35° 40′ north latitude, and 108° 15″ to 111° longitude west from Greenwich. Area, 17,952 square miles, of which 12,726 belong to Arizona and 5,226 to New Mexico. Adjacent published atlas sheets: NE. 69, E. 77, SE. 84, S. 83, W. 75, NW. 67.

GENERAL PHYSICAL FEATURES.

The area belongs orographically to the Colorado plateau system and consists in the main of a number of nearly flat or gently rolling table lands or mesas of varying extent, separated and cut into by steep-walled cañons of varying depths but nowhere approaching in size the gigantic chasms nearer the Colorado River. The general slope is toward the northwest, and the lowest point (about 4,600 feet) is in the bed of the Colorado Chiquito, where it leaves the area. The highest point is Green's Peak (10,093 feet above the sea) in the White Mountain Group (Sierra Blanca of Arizona). Other prominent ranges are the Datil in the southeast, with summits varying from 9,000 to 9,500 above sea, and the Zuni in the northeast, a little lower. The most imposing and most elevated of the mesas is the Mogollon, breaking abruptly to the south in cliffs varying from 600 to 1,000 feet. There are also four mountain groups, two plateaus, one mesa, one lake, ten principal peaks, and one cañon (Quivira).

DIVIDES AND DRAINAGE SYSTEMS.

A loop of the Continental Divide enters the area at Campbell's Pass (7,306 feet, approximately, above sea) a few miles to the eastward of Bacon Springs, and curving to the south and east along the crest of the Zuni Mountains incloses a small part of the Rio Grande Basin. The summit at the pass flattens out into a plain of considerable extent, and the dividing ridge is almost imperceptible. This divide again enters the area at Mangos Pass (7,977 feet) in the Datil Mountains at the head of the Burnt Fork, inclosing a second small extent of the Rio Grande area. With the above exceptions, the entire drainage belongs to the Great Colorado System, which is represented by portions of the basins of its tributaries, the Colorado Chiquito and the Gila. The comparatively small area belonging to the Gila Basin is south of the Mogollon Mesa. Nearly the whole section is therefore drained by the Rio Colorado Chiquito (Little Colorado or Flax River).

Geological exposures are in the Zuni Mountains, Carboniferous and some Archæan southward along the Marcou Buttes (extinct craters) to Piñon or Alamocita Mountains, Datil Range and White Mountains (Green's Peak) eruptive rocks (trachyte and basalt), which latter extends northward and westward from Green's Peak for 40 miles over the Carboniferous sandstone of eastern portions of the Mogollon Mesa. This unbroken volcanic area forms part of the great lava flow of New Mexico and Arizona, of which the boundaries were first determined by the operations of this survey 1871–'73 (see Vol. III, Chapter XIX) In the remainder and greater portion of the area the exposures are Cretaceous (Zuni Plateaus) and Triassic (plateaus north of Colorado Chiquito and Puerco Rivers), the former characterized by numerous sandstone-topped mesas with shaly bases, the latter by barren sandstones and clays weathering in fantastic forms.*

The Sunset Gap mesas are basalt-capped remnants of Triassic beds, consisting principally of red sandstone with about 72 feet of layers of gypsum and clay. Cañon Butte, at the mouth of Bouché's Fork, is similar.

At Sunset Crossing and above, the Little Colorado is not typical of the region, as it does not flow in a cañon, but on the contrary having a flood plain in places a mile or more in width. It occupies a monoclinal valley between the Carboniferous and Triassic. The whole area is substantially a plateau, with Archæan, Silurian, Carboniferous, Triassic, Cretaceous, and Igneous rocks, the detrital masses being inappreciable. One of the great lava-fields of the world extends from San Francisco Mountains to Mount Taylor, not less than 235 miles, consisting of a heavy body of fully 20,000 square miles in extent, with an arm reaching to the mountains above named. The rocks are (1) Basalt, (2) Sanidin-dolerite, and (3) Trachyte, with Basalt always on top and Trachyte at bottom. The Colorado Plateau, of which this sheet forms a part, has been estimated as high as 140,000 square miles.

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*For further geologic description see Chapters IX and X, Vol. III.

After heavy rains there is a still pond at Sunset Crossing, where salt deposits. The quantity is small, its taste disagreeable. It contains less than 79 per cent of common salt. At the Moqui villages, Arizona, as also at Mimbres, N. Mex., the subsoil was found to contain moisture, probably ascending from a subterranean stratum of water, sufficient for raising crops in these dry regions without irrigation. While the surface soil in the desert and detrital plain consists usually of pebbles, yet the subsoils usually have revealed all the constituents of fertility.

Climate and resources.—The climate is mild, with little snow in winter; it has already been described in general terms in Sheet 75. The following statistics for Fort Wingate, will give an idea of it as regards the *Zuñi* Mountain country. There is a well-marked rainy season in July and August.

The following summary from Post Hospital observations, from June, 1880, to July, 1883, has been made by the Signal Service for Fort Wingate, N. Mex. (latitude 35° 31′, longitude 108° 24′, altitude 7,038 feet): Mean annual temperature, 50.5° Fahr. (highest in July, with maximum of 92° Fahr. in June, 1881; lowest in January, with minimum of −16° Fahr. in January, 1883); average precipitation, 13.42 inches (greatest occurs in July).[*] Small belts of good bottom lands occur on the Colorado Chiquito, Bouché's Fork, Lithodendron Creek, Zuñi River, and on the heads of the Gila, south of the Mogollon Mesa, are many forest meadows and valleys suitable for stock raising, and where the hardier vegetables could be grown. Coal in workable quantities occurs at Stinking Springs, 12 miles west of Wingate.

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[*] The Signal Service has compiled rain-falls as follows: Old Fort Defiance, eight years eight months, between May, 1852, and March, 1861: Average, 13.84 inches; maximum, 22.44 inches, 1854, and minimum, 11.63 inches, 1856. Fort Wingate, twenty-one years six months, between December, 1864, and October, 1887: Average, 14.77 inches; maximum, 25.06 inches, 1873, and minimum 5.67 inches, 1879.

The country is not well watered, except in the mountain ranges. The Rio Colorado Chiquito is a muddy and tortuous stream below the Rio Puerco, but permanent for 30 or 40 miles below Sunset Crossing. Its waters have a slight taste of gypsum. The Puerco is little more than a muddy wash, without running water through half the year. Bouché's Fork is permanent, from 2 to 4 feet deep and 18 inches wide, and in 1873 abounded in fish.

Grazing.—The slopes of the mountains up to the timber, as a rule, grow bunch and grama grass sufficient for large herds. Reservoirs can be established near head of the Little Colorado.

Agriculture.—Irrigation is necessary as a rule, but in certain favored spots the Indians on Zuñi River raised good crops without it.

Timber.—Cottonwood occurs in the bottoms of all the main streams. In the Zuñi, Datil, White Mountains, and especially on the forest-clad Mogollon Mesa, large timber is found, the most valuable species being yellow pine (*Pinus Ponderosa*) and Douglass spruce (*A. Douglassii*). A small oak grows on the lower slopes. The timber of the lower mesas is mainly a sparse growth piñon and juniper, suitable for fuel only.

Routes of communication.—The Atlantic and Pacific Railroad (built since the sheet was issued), crosses the Continental Divide at Campbell's Pass (7,306 feet above sea), thence north of Fort Wingate, follows the valley of the Puerco to its junction with the Colorado Chiquito, which stream it follows to Sunset Crossing, from whence it ascends the plateau. From Manuelito, near the Arizona and New Mexico line, a stage road runs north to Defiance; from Holbrook (junction of Puerco and Colorado Chiquito) a stage road runs south, via Snowflake, about 90 miles to Camp Apache (in Sheet 83), also to Saint Johns and Springerville. Other main routes are the Prescott and Wingate road, entering the area at Sunset Tanks, following from Sunset Crossing the same course as the railroad, the Apache and Wingate road crossing the river north of Saint John's at the Colorado Bridge, and then passing via Zuñi Creek and mountains to Fort Wingate.

From Saint John's there is a through road to Los Lunas on the Rio Grande via Rito Quemado. From this point a through road continues south to Luera Springs (Sheet 84); and thence via Ojo Caliente to Fest's Ferry, on the Rio Grande.

Military posts, towns, and settlements.—The only military post is Fort Wingate, in the northeastern corner of the area, 3 miles south of Fort Wingate Station, on the Atlantic and Pacific Railroad.[*]

With the advent of the railroad new settlements and villages have sprung up. When first visited this entire region was little more than a roving and hunting ground for the Apache and other Indians.

SHEET 77.

Locality.—Central New Mexico.

Scale.—One inch = 8 miles or 1 : 506880. Area, 17,592 square miles. Boundaries, 34° and 35° 40′ north latitude, and 105° 30′ and 108° 15′ longitude west from Greenwich. Adjacent published sheets: N. 69, NE. 70 A and C, E. 78 A, S. 84, SW. 83, W. 76. Expeditionary years of 1871, 1873, 1874, 1875, 1876, 1877, 1878.[†]

GENERAL PHYSICAL FEATURES.

The whole sheet has examples of the ridge, plateau, butte, plain, and valley formations. The latter is principally a narrow strip along the Rio Grande. The plateaus and plains (the latter often quite desert in character) predominate. The main ridges lie to the east of the Rio Grande, while mountain groups rise from the plateaus at many points. The area lies almost wholly within the Rio Grande Basin, except a small portion belonging to the Pecos. The principal divide (the Continental lying to the west) is that between the Rio Grande and its eastern affluent, the Pecos. There are eight principal towns, all on the Rio Grande, together with various small Mexican settlements and Indian pueblos.

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[*] The principal settlements in 1878 were: Saint John's, a town of about 200 inhabitants, mostly Mexicans; Springerville, a thriving and growing settlement of 150 inhabitants, in a beautiful valley on the headwaters of the Rio Colorado Chiquito; Rito Quemado and Rito Mangos, small Mexican settlements on the Burnt Fork; also the villages of the Zuñi and Navajo Indians on Zuñi Creek and northwest of Fort Wingate.

[†] Quarter-sheets B and D constitute the eastern half of full sheet No. 77.

Outside of the narrow strip belonging to the Rio Grande this country consists of plateaus and mesas, with serrated ridges or cordilleras east of the river running nearly north and south. The persistent mesa plains impart a desert character to much of this region away from the Rio Grande, the soil of which, however, in many instances is highly fertile, needing only water to raise abundant crops, while at specified points through the sandy surface the Pueblo Indians have successfully raised crops by deep planting without irrigation. It can not, however, be said, outside of the narrow Rio Grande Valley, to be other than a pastoral and mining region. There are five main ranges, nine mountain groups, four plateaus, ten mesas, sixty-six principal peaks (four above 10,000 feet), one lake, four main cañons, and one mountain pass.†

Climate.—The following Signal Service summary is for observations from July, 1879, to May, 1881, at Socorro, N. Mex. (latitude 34° 5′, longitude 106° 55′, altitude 4,569 feet): mean annual temperature 56.3° Fahr. (highest in July, with maximum of 97° Fahr., in June, 1880; lowest in January, with minimum of —2° Fahr., in November, 1880), mean relative humidity 46.8; average precipitation 11.22 inches (greatest occurring in December, with south for prevailing wind).†

The present resources of this tract consist of the agricultural productions of the Rio Grande Valley, cattle raising on a large scale, timber for local markets, with mining at a great number of localities constantly on the increase.

The land classification for the sheet (17,592.24 square miles) is 4.35 per cent. for arable, 66.37 per cent. grazing, 17.53 per cent. timber, and 11.75 per cent. arid or barren.

Dr. Loew found, upon comparing chemically the compositions of the Rio Grande and Nile mud (see Vol. III, p. 578), the former to be richer in potassa, but with a less amount of phosphoric acid, with a greater absorptive power on account of an excess of hydrated oxide of iron. He concludes that the inhabitants of the Rio Grande Valley will never require any other fertilizer than the waters of that river.

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* Of the 4,466 square miles represented by 77 A 1,315 belong to the plateau, 521 to valley, and 2,630 to the plains, while for a like area in 77 B, 1,173 square miles are mountainous, 1,160 plateau, 984 valley, and 1,150 desert or barren, and for 77 D (4,510 square miles) 1,065 are mountainous, 1,060 plateau, 795 valley, and 1,590 plains.

† Further Signal Service compilations give: Albuquerque, twelve years ten months, between February, 1850, and August, 1879: average, 7.76 inches; maximum, 16.30 inches, 1856, and minimum 3.78 inches, 1860. Socorro, two years ten months, between November, 1849, and May, 1851: average, 8.01 inches (record at broken intervals).

The formations exposed between latitude 34° 15′ and 35° 15′ north, and longitude 105° 30′ and 106° 15′ are Archaean, Carboniferous, Cretaceous, and Tertiary, with patches of Igneous. Professor Stevenson gives the structure south from Galisteo Creek as Dakota, Colorado, and Laramie of the Cretaceous overlaid by Trachyte masses.

The following mining districts had been located in 1873–'74:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.	Printed reports.
			Long. west.		Lat. north.			
			°	′	°	′		
1	Spring Hill …	Dr. Loew	107	00	34	05	6,300, near Socorro Peak …………	Not reported
2	Old Placers…	… do …	106	15	35	20	7,000, Placer Mountains …………	Do.
3	La Joya ……	… do …	106	50	34	20	5,000, southeast of Ladrones Peak…	Do.
4	New Placers…	… do …	106	13	35	15	7,000, Tuerto Mountains …………	Do.
5	Los Cerillos…	… do …	106	08	35	27	6,000 Placer Mountains …………	Annual Report 1875, p. 107.

Routes.—The Atchison, Topeka and Santa Fe Railroad enters the area at approximately 35° 24′ north latitude, and extends westerly to Santo Domingo, on the Rio Grande. From Lamy Station a branch (distance 18 miles) reaches Santa Fe. The main line runs south along the valley of the Rio Grande, emerging from the sheet near Socorro. It effects a junction with the Atlantic and Pacific Railroad near the pueblo of Isletta. The direction of the Atlantic and Pacific is northwesterly, entering the area of Sheet 76 about 18 miles east of Fort Wingate. Numerous wagon roads are found delineated.*

SHEET 78 A.

Locality.—Part of northern New Mexico.

Scale.—One inch = 4 miles, or 1 : 253440. Area, 4,465 square miles. Boundaries, 34° 50′ and 35° 40′ north latitude, and 104° 7′ 30″ and 105° 30′ longitude west from Greenwich. Adjacent published sheets: N. 70 C, SW. 77, W. 77, NW. 69. Expeditionary years of 1874–'75.†

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* Total population (1880), 35,367, or approximating 9 to the square mile. Improved lands approximating 25,569 acres. There are thirteen Pueblo towns: Jemes, Silla, Santa Ana, Cochiti, Santo Domingo, San Felipe, Sandia, Isletta, Pecos, Laguna, Moquina, Pojuaque, and Acoma. Moquina and Pojuaque contain an admixture of Mexicans.

† This sheet is the northwest quarter of 78.

GENERAL PHYSICAL FEATURES.

The area is plateau and plain-like in character, forming the border between the typical rolling land of the Great Plains and the serrated head lands of the Staked Plains extending toward Texas. No mountains, even, interrupt the solitude and monotony of the landscape, and valleys, where occurring, are narrow erosions from the plateau and mesa beds.

The only divide of importance is that between the drainage of the Pecos and the Canadian. The former stream drains the greater portion of the territory that otherwise belongs to the Staked Plains. There are four principal settlements. This is purely a plateau and mesa country, interspersed with plains and narrow cañon-like valleys, of little value except for grazing.

There is, however, but little absolutely barren ground, with considerable timber about the cañons and the higher levels bordering the plateau edges.

There are no mountain ranges or groups, one plateau (Pecos), thirteen mesas, ten principal peaks, one lake, and four main cañons.

The observed land classification determines the following approximate values: 1.88 per cent. tillable, 76.82 per cent. grazing, 18.01 per cent. timber, and 3.29 per cent. arid or barren.*

The geologic formations at the northwestern corner, north of 35° 15′ latitude and west of longitude 105° 5′, are the Archæan, Carboniferous, Cretaceous, and Tertiary.†

Routes.—In the northwestern corner the Atchison, Topeka and Santa Fe Railroad passes southward along the eastern and southern base of the Santa Fe Range via Las Vegas,‡ Beresal, and Pecos.

SHEET 83.

Locality.—Parts of eastern and southeastern Arizona and western and southwestern New Mexico.

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* The Signal Service gives for rain-fall at Las Vegas, for one year ten months, between April, 1850, and January, 1876: Average, 23.46 inches.

† For further description see Sec. 3, Chap. XVI, Vol. III, Supplement, Geology.

‡ One-third of San Miguel County (approximately), with a population (1880) of 20,638, is comprised. The principal town is Las Vegas (1880), 6,000 inhabitants. Post-offices, eighteen (1880).

Scale.—One inch = 8 miles, or 1 : 506880. Area, 18,302 square miles. Boundaries, 32° 20′ and 34° north latitude, and 108° 15′ and 111° longitude west from Greenwich. Adjacent published sheets: NW. 75, N. 76, NE. 77, and E. 84. Expeditionary years of 1871 and 1873.

GENERAL PHYSICAL FEATURES.

Orographic systems.—The southern boundary of the Colorado Plateau, which was traced across Sheet 76, enters this area at the northwestern corner, passes north of the Sierra Ancha southeastward to Natanes Butte, thence easterly over a lava country, swinging gradually to the north to the Datil Range. South of the plateau system thus inclosed lies a region of mountain ranges, approaching parallelism, with intervening detrital valleys. They belong to the western group of the mountain ranges of Arizona and New Mexico, and are related by their trend to the Basin Ranges, as the eastern group is to the Rocky Mountain System of Colorado, as explained in relation to Sheet 84. There are seven principal ranges, ten mountain groups, three plateaus, one lake, twenty-six well-defined peaks (four above 10,000 feet), four main mountain passes, and four cañons.

The lowest point in the area is where the Gila leaves it (about 2,000 feet above sea), and the highest Thomas Peak (altitude 11,496 feet), in the White Mountains, or Sierra Blanca Range of Arizona.

A loop of the Continental Divide enters the northeastern corner of the area, following the northern crest of the Tulerosa Range to near latitude 33° 30′, where it swings northeast. A bay of the Rio Grande Basin is thus inclosed, being a western extension of the San Augustin Plains, here marked by a depression containing a saline marsh. The following is from Dr. Loew as to the geographic distribution of plants:[*] (See Vol. III, p. 603.)

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[*] The regions of the southwest may be divided into four distinct zones (according to altitude):

(1) Zone of Cactus, Yucca, and Agave; altitude, 3,000 to 3,500 feet. Grass is scanty. Where there is water a most luxuriant vegetation springs up.

(2) Zone of Obione and Artemisia (greasewood and sage-brush); altitude, 3,500 to 4,900 feet. Grass is poor, with few exceptions, on granitic and volcanic soil. The cactus species are diminished in number.

(3) Zone of *Juniperus occidentalis* (cedar); altitude, 4,900 to 6,800 feet. Cactus species few.

(4) Zone of Pine and Fir; 6,800 to 10,600 feet (highest points).

Extensive forests occur, especially above 8,000 feet, while below 6,000 feet the country assumes a semi-desert character, and finally the true desert form at lower levels, and especially toward the lower main Colorado and Gila Rivers. It has been proved that the bottom-lands of the San Pedro and Gila Rivers are exceedingly fertile, as also the upper Gila near Old Fort West, while fine timber abounds in the Burro and Mimbres Mountains.

The following meteorologic summaries serve to give some idea of the atmospheric conditions at points within and adjacent to this sheet:

Fort Apache, Ariz., from October, 1877, to July, 1883 (latitude 33° 48′, longitude 109° 57′, altitude 5,050 feet): Mean annual temperature, 52.1° Fahr. (highest occurs in July, with maximum of 102.5° Fahr in July, 1881; lowest in January, with minimum of —9° Fahr. in February, 1880); mean relative humidity, 50.2; average precipitation, 22.98 inches (greatest occurring in July and August), with prevailing wind east.

Silver City, N. Mex., from May, 1878, to June, 1883 (latitude 32° 46′, longitude 108° 14′, altitude 5,890 feet): Mean annual temperature, 54° Fahr. (highest in July, with maximum of 99° Fahr. in June, 1881, and July, 1882; lowest in January, with minimum of 5° Fahr. in December, 1880); mean relative humidity, 48.6; average precipitation, 20.16 inches (greatest occurs in August); prevailing wind, northwest.

Old Camp Goodwin, Ariz., from September, 1877, to July, 1883 (latitude 33° 4′, longitude 110° 2′, altitude 2,710 feet): Mean annual temperature, 60.7° Fahr. (highest in July, with maximum of 109° Fahr. in July, 1881; lowest in January, with minimum of 14° Fahr. in January, 1881); mean relative humidity, 50.6; average precipitation, 9.26 inches (greatest occurs in August); prevailing wind, northwest.

Fort Grant, Ariz., from November, 1875, to July, 1883 (latitude 32° 39′, longitude 109° 57′, altitude 4,860 feet): Mean annual temperature, 60.2° Fahr. (highest in July, with maximum of 103° in August, 1879; lowest in January, with minimum of 17° Fahr. in January, 1880, and January, 1881); prevailing wind, north.

Florence, Ariz., from November, 1875, to April, 1882 (latitude 33° 3′, longitude 111° 19′, altitude, 1,480 feet): Mean annual temperature, 68.6°

Fahr. (highest in July, with maximum of 116° in July, 1879; lowest in January, with minimum of 19° Fahr. in December, 1879); mean relative humidity, 43.1; average precipitation, 9.61 inches (greatest in August); prevailing wind, west.

Fort Bowie, Ariz., from June, 1880, to July, 1883 (latitude 32° 8′, longitude 109° 30′, altitude 4,872 feet): Mean annual temperature, 63° Fahr. (highest in June, with maximum of 106° Fahr. in June, 1881; lowest in January, with minimum of 13° Fahr. in January, 1883); average precipitation, 16.16 inches (greatest in July).

Fort Lowell, Ariz., from January, 1871, to June, 1883 (latitude 32° 12′, longitude 110° 52′, altitude 2,000 feet): Mean annual temperature, 65.9 Fahr. (highest in June, with maximum of 115° Fahr. in August, 1881; lowest in January, with minimum of 0° Fahr. in January, 1883); average precipitation, 11.49 inches (greatest in August).

Fort Thomas (latitude 32° 4′, longitude 110° 6′, altitude 2,710), mean of four years: Mean annual temperature, 60.9 Fahr. (highest occurs in July, with maximum of 109° Fahr.; lowest in January, with minimum of 12.8 Fahr.); mean relative humidity, 50.9; average precipitation, 9.77 inches (greatest in August); prevailing winds: spring, west; summer and autumn, southeast; winter, northwest.*

The orographic systems are composed, geologically, of the Archæan, Silurian, Carboniferous, Triassic, and Igneous formations; the valleys, of Quaternary.†

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* The last two stations are from Post Hospital Reports, the others from the Signal Service. The latitudes, longitudes, and altitudes are approximate only. The Signal Service gives further summaries for rain-falls as follows: Fort Apache, twelve years four months, between May, 1875, and November, 1887: Average, 21.34 inches; maximum, 31.19 inches, 1881, and minimum, 12.41 inches, 1877. Camp San Carlos, six years six months, between June, 1881, and December, 1887: Average, 13.36 inches; maximum, 20.41 inches, 1884, and minimum, 8.18 inches, 1885. Fort Grant (combined with old Camp Grant), nineteen years seven months, between September, 1866, and December, 1877: Average, 16.65 inches; maximum, 25.67 inches, 1864, and minimum, 8.95 inches, 1870. Old Camp Goodwin, three years eleven months, between January, 1866, and May, 1870: Average, 26.56 inches; maximum, 27.93 inches, 1867, and minimum, 16 inches, 1868. Camp Thomas (Gila Valley), seven years nine months, between April, 1880, and December, 1887: Average, 10.74 inches; maximum, 18.16 inches, 1884, and minimum, 8.66 inches, 1882. Old Fort Tularosa, one year five months; between May, 1873, and October, 1874: Average, 23.13 inches. Silver City, four years eleven months, between May, 1878, and March, 1883: Average, 20.26 inches; maximum, 30.89 inches, 1881, and minimum, 13.77 inches, 1879.

† West of the Mimbres River the trend of the mountain ranges is northwest. They disappear northward under the lavas of the plateau. The axial rocks are Archæan and Paleozoic, post-Carboniferous in age. The ranges (usually monoclinal) all show post-Carboniferous volcanic rocks, including

The following mining districts had been located in 1871–'73:

No.	Name.	By whom visited.	Approximate geographical position.		Remarks.	Printed reports.
			Long. west.	Lat. north.		
			° ′	° ′		
1	Pinal	Lt. Lockwood Dr. Hoffman	110 55	33 17	Pinal Range	Prog. Rep., 1871, p. 58.
2	Chloride	Dr. Loew	108 15	32 45	6,000 feet, near Bear Peak	Not reported.
3	Silver Flat	do	108 15	32 44	6,000 feet, near Silver City	Not reported.
4	Burro Mountain	do	108 35	32 36	6,500 feet, Burro Mountains	Not reported.
5	Copper Mountain	do	109 30	33 10	5,800 feet, southeast of Gray Peak	Not reported.

Routes.—The Southern Pacific Railroad enters a little west of the New Mexico boundary, thence via Railroad Pass, leaving approximately with the road southward from Camp Grant. Various wagon roads are delineated.*

ATLAS SHEET 84.

Locality.—Part of southwestern New Mexico.

Scale.—One inch = 8 miles or 1 : 506880. Boundaries, 32° 20′ to 34° north latitude, and 105° 30′ to 108° 15′ longitude west from Greenwich Area, 18,302 square miles, of which 1,400 square miles in the southeastern section (84 D) were not surveyed. The northeastern and southwestern sections (Atlas Sheets 84 B and 84 C) have been issued separately on a scale of 1 inch to 4 miles or 1: 253440. Adjacent published sheets: NW. 76, N. 77, W. 83.

GENERAL PHYSICAL FEATURES.

Orographical systems.—The mountain ranges of Arizona and New Mexico, as they extend northward from the plateau of the Sierra Madre in latitude 32°, have been divided into an eastern and western group, distinguished by a difference of trend of the axes of corrugation (Vol. III,

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granite, feldspathic porphyry, propylite ? trachyte, rhyolite, basalt, and quartz porphyry. Vein matter carrying gold is found in the Syenite of the Chiricahui Range; cupriferous veins in quartzite in the Gila Range quartz veins, with argentiferous ores, in the volcanic rocks of the Pyramid Range; gold in placer, near Clifton; also copper in Paleozoic limestone, and argentiferous galena in Silurian limestone, and shale at Silver City. (See Vol. III.)

* The largest town is Silver City, 1,800 inhabitants (1880). Since visiting the area, which is true, also, for every atlas sheet published, many new mining camps, towns, and settlements have sprung up, and others have increased and developed. The White Mountain Indian Reservation embraces fully one-third of the whole area.

Geology, Chap. XVIII, Gilbert). The latter group has a northwestern trend, as illustrated in Sheets 76 and 83 by the Pinaleño, Pinal, Mazatzal, and ranges to the west, and when traced northward is found to gradually change its direction, finally coalescing without discernible break with the Basin Ranges of Utah and Nevada which trend north and south. The mountains of the eastern system have a marked north and south trend and are the southern continuation of the Rocky Mountain system of Colorado, and with them form the eastern boundary of the Colorado Plateau region, while the western group marks its southern terminus.

To the eastern systems belong all the mountains of this area, which are here arranged in four great groups trending north and south, and including between them three great plains. Of the area of 84 B (4,554 square miles) 2,412 square miles are mountainous, 268 plateau, 267 valley, 1,340 plains, and 267 desert.

The mountains in the west of the area are known as the Mimbres, San Mateo, and Magdalena Ranges, in the west center as the Sierra de los Caballos and the Fra Cristobal Range, in the east center as the Organ, San Andreas, and Oscuro, and in the east as the Sacramento, Sierra Blanca (of New Mexico), Carrizo, and Jicarilla Ranges. There are seven principal ranges, seven groups of mountains, three plateaus, one mesa, forty-nine prominent peaks (five above 10,000 feet), four mountain passes, and three main cañons.

DIVIDES AND DRAINAGE SYSTEMS.

The Continental Divide follows the crest of the Mimbres Range to Mimbres Head, then swings to the southwest, thus inclosing an area belonging to the Colorado Basin, here drained by the Gila. South of this is the Mimbres drainage, which belongs to an interior basin, reaching its greatest depression just south of the Mexican line in Palomas Lake. With these exceptions the area belongs to the Great Rio Grande Basin, that river itself flowing centrally through it from north to south. The plains of San Augustin in the northwest of the sheet have at their lowest point an alkaline marsh about 6,700 feet above sea, and though without a surface outlet still lie wholly within the Rio Grande area. The same may be said of the vast

Mal-pais plain, reaching its greatest depression in a salt marsh 3,800 feet above sea, which is the lowest point in this atlas sheet, Sierra Blanca Peak, 11,892 feet above sea, being the highest. The eastern slopes of the Sacramento, Sierra Blanca, and northern ranges drain to the Rio Pecos, the principal tributary of the Rio Grande.

Geological exposures.—No connected geological reconnaisance was made throughout this area, but it may be of interest to record here the principal exposures noted. The mountain area from the Antelope to the San Augustin Plains, and west of the Mimbres crest, belong to the great lava flow of New Mexico and Arizona, mentioned in reference to sheets 76, 77, and 83. The western slope of the Mimbres Range is an almost continuous sheet of trachytic lava. The range itself is considered a great monoclinal uplift with westward dip, composed in chief part of lava, including the crest, but revealing the underlying sedimentaries (Paleozoic) along the eastern base. The Negrita Hills between the Mimbres and San Mateo Ranges are masses of dark plutonic rock. The country rock of San Mateo Peak (the southern and most prominent, though not the highest of that range) is trachyte with basaltic outcropping of later date about its base. The country rock of the Magdalena Range (a rugged group contrasting strongly with the lava forms to the westward and culminating in a peak 10,798 feet above sea) is to the south granitic and to the north granitic capped with carboniferous limestone. The Fra Cristobal Mountains, rising precipitously 2,500 feet above the Rio Grande, are metamorphosed sandstone capped with limestone. At the north the dip is to the west, further south the strata are nearly horizontal, while at the extreme southern end and in the Caballos the dip is to the east.

The Oscuro and San Andreas Ranges are sedimentary uplifts, anticlinal and capped with limestone, and lie in a line of upheaval extending from the Placer Mountains in north central New Mexico to the Franklins at the southern boundary. The dip in the Oscuros is eastward, which approaches the horizontal at San Andreas Pass and changes to the westward as we go south into the range of that name. To the east of this uplift lies the desolate Mal-pais Plain, probably the bed of a cretaceous sea, marked at the north by a remarkable lava outburst of recent date, which has flowed over 40 miles southward from a small crater at the north. The plain reaches its greatest depression in a marsh, strongly impregnated with saline matter, largely common salt. To the southeast of the marsh is a singular accumulation of gypsiferous sand, perhaps 30 feet in depth, dazzling white and slowly drifting southeastward under the influence of the prevailing winds. Limiting this plain upon the east is the Sierra Blanca of New Mexico, with its northern outliers, the Noyal, Carrizo and Jicarilla Mountains, while farther south the great mesa wall of the Sacramento Mountains forms the eastern limit.* East of the Mimbres Range the ridges trend north and south, being a continuation of the Rocky Mountains, *so called*, and the eastern boundary of the Colorado Plateau. The rocks are mainly Archæan and Carboniferous with Silurian toward the boundary, flanked by Cretaceous and other Mesozoic strata. The last great upheaval, as stated by Gilbert, begun before the close of the Cretaceous. Argentiferous galena is found in Carboniferous limestone in the Upper Mimbres. The Santa Clara District on the western slope of the Santa Rita Range consists of argentiferous ores in Carboniferous limestone. The famous Santa Rita Mine is on the contact between the limestone and porphyry.

Sierra Blanca Peak, one of the most striking mountain masses in the West, rising boldly nearly 7,000 feet above its eastern base, is a great mass of eruptive rock, largely quartzite, trachyte-porphyry, and graphic granite. About its base and even high up upon its flanks are exposures of the sedimentary beds through which it has been thrust, and especially noteworthy is a horizontal limestone exposure from the west, near the top of the ridge south of Nogal Peak. The high outlying ridges of the Sierra

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*The Signal Service publishes rain-falls as follows: Old Fort Craig, twenty-one years three months, between January, 1855, and December, 1884: Average, 11.50 inches; maximum, 24.58 inches, 1869, and minimum, 4.63 inches, 1858. Old Fort McRae, five years nine months, between April, 1864, and January, 1876: Average, 11.10 inches; maximum, 13.45 inches, 1869, and minimum, 5.97 inches, 1873. Fort Stanton, twelve years eight months, between January, 1856, and December, 1887: Average, 19.55 inches; maximum, 28.70 inches, 1857, and minimum, 13.65 inches, 1860. Old Fort Thorn, four years eleven months, between January, 1854, and December, 1858: Average, 14.71 inches; maximum, 20.55 inches, 1857, and minimum, 10.58 inches, 1858. Old Fort Selden, twelve years three months, between November, 1865, and October, 1887: Average, 8.49 inches; maximum, 12.09 inches, 1869, and minimum, 3.49 inches, 1873. Fort Bayard, twelve years five months, between March, 1867, and October, 1887: Average, 14.78 inches; maximum, 22.18 inches, 1873, and minimum, 6.44 inches, 1871. Old Fort Cummings, four years four months, between March, 1869, and July, 1873: Average, 15.03 inches; maximum, 20.55 inches, 1870, and minimum 10.79 inches, 1871.

Blanca, where not of volcanic origin, have the same formation of sandstone capped with limestone as well as the Sacramento Mountains, which are properly a great plateau-like uplift of sedimentary strata with a deeply eroded surface sloping generally eastward. The western edge is a bold mesa bluff, perhaps 3,000 feet high near the center, breaking down southward into a series of comparatively low broken hills.*

The following summaries are from the record of the Signal Office:

La Mesilla, N. Mex., from August, 1877, to August, 1882 (latitude 32° 16′, longitude 106° 49′, altitude 3,900 feet); mean annual temperature, 60° 3 Fahr. (highest in July, with maximum of 107°.8 Fahr. in June, 1881, lowest in January, with minimum of 2° Fahr. in December, 1880); mean relative humidity, 43.3; average precipitation, 8.9 inches (greatest in July); prevailing wind, west. Fort Craig, N. Mex., from July, 1878, to July, 1879 (latitude 33° 38′, longitude 107° 1′, altitude 4,448); mean annual temperature, 60°.3 Fahr. (highest in August, with maximum of 102° Fahr. in July, 1878, lowest in December, with minimum of 2° Fahr. in January, 1879); precipitation greatest in January.

The following mining districts were visited in 1873 and 1874:

No.	Name.	By whom visited.	Approximate geographical position.				Remarks.
			Long. west.		Lat. north.		
			°	′	°	′	
1	Central	Doctor Loew	108	10	32	50	5,000 feet.
2	Pinos Altos	G. K. Gilbert	108	14	32	46	6,000 feet.
3	Upper Mimbres	do	108	05	32	50	6,000 feet.

Agriculture —At Cañada Alamosa several hundred acres are irrigated, as also the bed of the Mimbres, from a few miles above McKnight's to Crittenden's, below Mimbres. Water sometimes scarce in May and June; fine crops of potatoes and grass at Piños Altos and Fort Bayard. Along the Rio Grande are fertile bottom lands, capable of irrigation, varying in width from 3 miles to a few hundred feet, where all the fruits and vegetables of this latitude are grown. The soil is especially adapted to grape culture. Much more land could be brought under cultivation by proper irrigation.

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* The hot springs of Silver City are described, see A. R., 1879, p. 250 et seq.

In the Mimbres Mountains a good supply of lumber and fuel timber occurs, such as pine, cedar, and oak. Heavy pine timber is abundant upon the flanks of the San Mateo and Magdalena Mountains, while the principal streams show cottonwood, aspen, and scrub oak.

The same may be said of the Sierra Blanca and Sacramento Ranges eastwardly, while piñon and cedar, with some oak, is quite plentiful upon the slopes of the Carrizo and Jicarilla Mountains to the north.

A dense growth of piñon and cedar covers the east slopes of the Oscura and the Chupadera mesas. The Magdalena, Caballos, and the Fra Cristobal Ranges are devoid of timber. Cottonwood occurs, here and there, in groves along the Rio Grande.

Grazing.—Nearly everywhere throughout this entire area nutritious wild grasses grow. Even the great dry plain, the Jornado del Muerto, and its northern extension, as well as the dreary Mal-pais Plain, are covered with good grama-grass. Their lack of surface water prevents the greater portion being utilized for stock ranges. The proportion of utterly barren and worthless lands is comparatively small, and is confined almost entirely to the rocky crests of the mountains. The approximate amounts of the classes of lands have been shown by colors on the southwest and northeast sections of this area (L. C. Sheets 84 B and C), and are given in square miles. 84 B: Total area, 4,554 square miles, of which 32 square miles, or .7 per cent., are arable; 3,480 square miles, or 76.4 per cent., grazing; 872 square miles, or 19.2 per cent., timber; 170 square miles, or 3.7 per cent., barren. 84 C: Total area, 4,597 square miles, of which 154 square miles, or 3.4 per cent., arable; 3,[illegible]73 square miles, or 79.9 per cent., grazing; 733 square miles, or 15.9 per cent. timber, and 37 square miles, or .8 per cent, arid or barren.

The climate is temperate and healthful, with the usual New Mexican characteristics of an exceedingly clear, dry, and pure atmosphere, with a rainy season in July, August, and September, when thunder storms are frequent in the principal mountains. Heat seldom oppressive; nights generally cool. The precipitation is nowhere great, but the following localities are noted as excessively devoid of flowing water: The Sierra Magdalena, Caballos, and Fra Cristobal.

LAKE TAHOE REGION (SIERRA NEVADA).

Scale of original, 1 inch = 1 mile, or 1 : 63360. Scale of publication, 1 : 42240. Area, 2,394 square miles. Boundaries, 38° 45′ and 39° 32′ north latitude, and 119° 33′ and 120° 22′ 30″ longitude west from Greenwich.*

Lake Tahoe is shown between the main crest of the Sierra Nevada on the west (locally the western summit) and a lofty spur on the east called the Tahoe Range (locally the eastern summit). This lake lies 6,202 feet above sea, is about 21 miles long by 12 broad, deep, with an approximate area of 188 square miles. It is a veritable gem in a mountain setting. The most prominent peaks of the main Sierra are Tallac, 9,715 feet; Rubicon, 9,284 feet; Twin, 8,824 feet; and of the Tahoe Range, Freels, 10,849 feet; Monument, 10,035 feet; Genoa, 9,155 feet, and Rose, 10,820 feet. Directly east of the Tahoe Mountains is the Carson Valley, well watered and fertile, with an average altitude of 4,600 feet. It is terminated on the east by the foot-hills of the Pine Nut Mountains. North of Carson Valley are Eagle, Washoe, and Steam-boat Valleys and Truckee Meadows. East of this chain of small valleys are the Washoe Mountains, including Mount Davidson, McClellan, and other prominent peaks.

The important towns are Carson, capital of Nevada, in Eagle Valley; Virginia, on the eastern slope of Mount Davidson; Reno, Boca, Verdi, and Truckee, on the Central Pacific Railroad, together with Genoa, in Carson Valley, Empire, Dayton, Silver City, Gold Hill, Glenbrook, and Tahoe City, on Lake Tahoe.

The Central Pacific Railroad is shown traversing the Truckee Cañon and crossing the Sierra in the vicinity of Donner Lake. Virginia and Carson have railroad connection with the Central Pacific at Reno. A portion of the Carson and Colorado Railroad runs east from Mound House. Whitney conceives Lake Tahoe and its surrounding valley to be the result of local subsidence similar to the Yosemite, because of its surface depth below the mountain crests on each side and its parallelism with the mountain axis. The lake is now very deep (over 1,600 feet), and the amount of detritus received by it already is unknown. The mountain range is granite.

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* This map was reproduced by the Heliogravure process at the Imperial Royal Military Geographical Institute, Vienna.

Lake Tahoe is a natural reservoir, the value of which could be materially enhanced for irrigation and purposes of water supply generally by increasing its capacity by a dam where it enters the Truckee. The extent to which this may be done can be ascertained by an engineer's examination and survey of the local conditions, out of which would grow the position, plan, and cost of the construction required. A project was at one time presented having in view the making of this exceedingly pure water available for the supply of San Francisco.

RESTORED OUTLINE OF LAKE BONNEVILLE.[*]

Locality.—Portions of western Utah and eastern Nevada, embracing parts of Atlas Sheets 40, 41, 42, 49, 50, 51, 58, 59, 60, 66, and 67.

This unnumbered sheet exhibits the location of a great fresh-water lake of the glacial period, first noticed by the writer during the expedition of 1869 near the summit of the Snake Range in Nevada, afterwards traced and its ancient beaches delineated in 1871 and later years by the expeditionary parties, and for which Mr. G. K. Gilbert suggested the name of Lake Bonneville in honor of the earliest scientific explorer of this region. This ancient lake extended over an area equal in extent to Lake Huron and included the valleys in which are now found Salt, Sevier, and Utah Lakes. A northern outlet toward the Columbia was subsequently determined to be at Red Rock Pass, at the northwestern arm of Malade Valley, about 4,900 feet above sea.

No southerly outlet was found, and it is doubtful whether one ever existed. There are many bays, joining the main body by narrow straits, with cañoned walls, especially in the more northerly portions traced during later expeditions. The altitude of the main or "Bonneville" beach is 5,178 feet.[†]

Lakes Bonneville and La Hontan[‡] are the principal Quaternary lakes that occupied portions of the Great Interior Basin.[§]

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[*] It belongs to the Geological Atlas. (See p. 58, List of Reports and Maps.)

[†] The vestiges of the lake are described as glacial phenomena on p. 91 *et seq.*, Vol. III, Geology.

[‡] See U. S. Geol. Survey, Monograph XI, Russell, Geological History of Lake La Hontan; also King, Vol. I, Fortieth Parallel Reports.

[§] The Great Basin is limited on the west by the abrupt eastern wall of the Sierra Nevada and other ranges to the southward, on the east substantially by the great mountain mass of the Wahsatch, The numerous terraces and shore-lines incident to each indicate the relative conditions of humidity at intervals in the progress of desiccation.

Gilbert found for Bonneville two principal shore-lines, prominently marked and easily traced, the "Bonneville" and "Provo," the latter about 400 feet lower than the former, and corresponding, doubtless, to the long-continued lowest level at which the old lake had an outlet over the hard limestone through Red Rock Pass. Between these two there are four or five comparatively well-marked shore-lines, and only one well distinguished below the Provo line.

The lake was undoubtedly fresh for all levels above the Provo, and probably salt when lower and without outlet.

King gives the surface of La Hontan at 4,388 feet and about 800 feet lower than Bonneville, noting the difference in the terraces and shore-lines in the great abundance of calcareous tufa for La Hontan. Russell says that no outlet for La Hontan was discovered, north or south.

King assumes from geologic evidence that the present and another period of desiccation in the Great Basin during the Quaternary were each preceded by a period of long-continued humidity, the first of which was probably directly correlated with the earliest and greatest Glacier period, and the second with the later Reindeer Glacier period. He states also that the Quaternary lakes show "that the two glacial ages, whatever may have been their temperature conditions, were in themselves each distinctly an age of moisture, and that the interglacial period was one of intense dryness, equal in aridity to the present epoch."

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to the southward by the irregular rim of the water-shed of the Colorado, and the northward by a similar line as regards the Columbia. Its entire perimeter has now been traced. Its dimensions are approximately 800 miles north and south and 500 miles east and west, with an area of 208,000 square miles. This large district is without outlet to the ocean, returning to the atmosphere the total precipitation less that held in reservoir. Between the eastern and western barriers are many long and narrow ranges averaging from 5,000 to 8,000 feet, usually meridional, quite regular and parallel, steep on one side and sloping on the other, ordinarily monoclinal, which surround plain-like valleys with a surface level of 4,000 to 5,000 feet at the north, descending southerly to the sea-level and below in Death Valley, all floored by detritus from the mountains, concealing their depths, and into which flow considerable streams that finally reservoir in saline and alkaline lakes. The average rainfall in this region is exceedingly small.* King states that the post-Pliocene of this area, during which there were two distinct glacial epochs, was marked by "a very long period of very great humidity, followed by a period of intense dryness," equal in aridity to the present, which gave way to a briefer period of humidity, which was rapidly succeeded by the present age of desiccation.

*See Signal Service compilations.

Russell found terraces of a Quaternary lake traced on old moraines of great magnitude deposited west of and near Mono Lake. He concludes that the greatest extension of the glaciers preceded the maximum rise of Mono Lake, the lacustral record of which indicate two periods of high water, and he mentions two well-marked glacial epochs in the Sierra Nevada. Gilbert states that the Bonneville and Provo shore-lines are neither horizontal nor parallel, and also that the region along the eastern margin of Bonneville has recently undergone depression, and presumably is still subsiding, and that there is no warrant for assuming that the end of volcanic activity in the Bonneville region has been reached.*

The following summary of conclusions, by G. K. Gilbert, appears on page 200, Second Annual Report, U. S. Geological Survey:

> (1) The climatic episode, of which Lake Bonneville was the expression, consisted of two humid maxima, separated by an interval of extreme aridity. The second maximum was the more pronounced; the first the longer.
>
> (2) The time elapsed since the close of the Bonneville epoch has been briefer than the epoch, and the two together are incomparably briefer than such a geologic period as the Tertiary.
>
> (3) The period of volcanic activity in the Great Basin, which covered a large share of Tertiary time, continued through the Quatenary also, and presumably has not yet ended.
>
> (4) Such earth movements as are concerned in the molding of continents had not ceased in western Utah at the close of the Bonneville epoch, and presumably have not yet ceased.
>
> (5) The Wahsatch Range, the greatest mountain mass of Utah, has recently increased in height, and presumably is still growing.

The future history of the humid conditions and changes in the Great Basin depend upon meteorologic conditions, only now partially understood.

TOPOGRAPHIC MAP OF YOSEMITE VALLEY AND VICINITY.

Locality.—Part of eastern central California. (Sheet 56 D.)

Scale.—One and three-fifths inches = 1 mile, or 1:39600. Boundaries, 37° 40′ 15″ to 37° 48′ north latitude, and 119° 28′ 15″ to 119° 42′ longitude west from Greenwich.

This map (the original of which on a much larger scale was constructed in contours) with hachures to represent the steeper slopes at and about the summits of the peaks and plateau—cañon-shaped walls—has been reproduced in hachures, and is complemented by a list of distances and elevations prepared by Lieutenant Macomb, found in an earlier part of the volume, which together make quite an intelligent description of and guide to this wonderful and unique mountain region. The valley proper is shown in considerable detail, while the outlying mountain ridges and foothills are delineated in the usual manner. This abundance of detail renders it almost unnecessary, from a topographic point, to enlarge upon the description. The area comprises a section of the western flank of the Sierra Nevada, which embraces the cañon-like valley of the Yosemite, included in the Merced drainage.

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* It is stated that a monograph on Lake Bonneville, by G. K. Gilbert, is in preparation. (See advertisement, U. S. Geological Survey.)

This valley, about 8 miles long and from one-half to 1 mile in width, situated on the Merced River, is characterized by nearly perpendicular walls of granite of great heights, as compared with its width and the small amount of débris or talus at the bottom of the cliffs. It possesses features, beautiful in their grandeur and sublimity, that are scarcely surpassed, and its counterpart is unknown.

El Capitan is 3,300 feet; Cathedral Rock, 3,000; Sentinel Dome, 4,150; Half Dome, 4,737 (absolutely vertical for 2,000 feet), and surrounding cliffs and peaks 7,000 to 9,000 above the level of the valley (about 3,900 feet). The Bridal Veil Fall is 1,000 feet high, the Yosemite 1,500, the Vernal 475, and the Nevada 894 feet. The fall in the valley is approximately 50 feet. In the landscape are groves of trees and flowers, brilliant in contrast with the neutral tinted rocks. Pitch pine (*P. ponderosa*) 125 to 150 feet high, also *P. Jeffreyi*, a few sugar pines, white oak (*Q. labata*) and evergreen oak (*Q. crassipocula*), willows, poplars, and cedars on the cliffs, are noted. Whitney finds the trees the same as about Mount Shasta, except more black oaks (*Q. Sonomensis*). The Half Dome is unique. Most great cañons and valleys of the Sierra Nevada are the result of denudation. Whitney concludes theoretically that this one was the result of upheaval while the granite was in a semi-plastic condition below its surface, that the Half Dome was split asunder, and that the valley proper was formed by the subsidence of a limited area sinking to an unknown depth, because of its support from underneath being withdrawn. King found evidence of a former glacier, probably 1,000 feet thick, in the valley, and the lateral cañons are polished and grooved.* It may be remarked that its peculiar shape can not be accounted for by the usual phenomena presented as the result of the upheaval and subsidence of the earth's crust.

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* See "The Yosemite Guide Book," Whitney, 1869.

King describes[*] the granite of El Capitan as homogeneous, but including irregular masses of different mineralogical composition.

Its smoothly fractured face is a uniform gray granite, in which are masses, as if segregations of certain mineral components, which as a whole is characterized by "a high proportion of plagioclase, hornblende, and titanite."

OUTLINE AND TOPOGRAPHIC MAP OF WASHOE MINING REGION, NEVADA.

The outline map, in one sheet, engraved on stone (printed with contours in brown), embraces more especially the vicinity of the Comstock lode and indicates the location of mineral claims, patented and unpatented, shafts, mills, mining towns, etc., on scale 1 inch = 2,000 feet, or 1 : 24000. The topographic map includes a greater area and is engraved in two sheets, on stone, showing contour lines of 50 feet interval; scale, 1 inch = 1,500 feet, or 1 : 18000. This map has resulted from a typical plane-table survey based on initial astronomic, geodetic, and trigonometric positions, further supported by measured and developed base-lines. It is valuable as a ground map for all military, economic, and scientific purposes, and sufficiently ample for all delineations of land classification, geology, etc., and also to aid in a thorough and complete analysis of this lode from all avenues of scientific inquiry, establishing data for all general profiles from well-determined bench marks.[†]

King states, as characteristic features, that both the Sierra and Desert Ranges are composed (1) of crumpled and uplifted strata from the late Jurassic down to the Azoic; (2) ancient eruptive rocks accompanying the Jurassic upheaval; (3) modern eruptive volcanic rocks, ranging probably from as early as the late Miocene up to the Glacial period. Folds of more or less complexity, twisted and warped by longitudinal forces, often compressed into zigzags, sometimes masked by outbursts of granite or syenite, and lastly built upon by or frequently buried beneath immense accumulations of volcanic material. The Basin Ranges are usually meridional and parallel, separated by valleys filled with Quaternary. The Virginia Range is one of the older Jurassic folds of stratified rocks, through whose fissures granite and syenite have obtruded. After a long repose from early Cretaceous to late Tertiary the range was riven and deluged by floods of volcanic rocks. During the volcanic period the valleys were partly filled by fresh-water lakes. Water penetrated the fissured range, which, meeting the melted rock, gave rise to the solfataras and hot springs. Then followed the Glacial age with its floods and torrents, and finally the present extreme desiccation period. The district proper consists of an accumulation of volcanic rocks built upon the Virginia Range, which together are an epitome of the whole Great Basin, representing within narrow limits every important geological event of the Cordillera system.

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[*] See Vol. I, Fortieth Parallel Reports, p. 120.

[†] This class of survey is now employed by the U. S. Geological Survey at the prominent mining districts investigated by them. The curves of the topographic map for a portion of the area, together with the outlines of the mining claims, have been employed and appear identically represented on Atlas Sheet 3 of Geology of the Comstock Lode, etc., by the U. S. Geological Survey, wherein, except for the words "Topography by U. S. Geographical Surveys west of the one hundredth meridian," the result (not in harmony with the fact), as a whole, would appear to have been produced by the former organization.

In the late Tertiary came the outflow of immense volumes of propylite, followed by the earlier andesites, which brought the solfataras and gradually filled the fissures with concentrations of metal-bearing quartz. The later andesite flows poured out over the decomposed propylite. Outside the vein occurred eruptions, when great volumes of Sanidin-Trachyte overflowed the country, as also the lesser basaltic eruptions that marked the close of the volcanic era.

Mount Davidson is considered as a relic of syenite, against the outer base of which are grouped metamorphic rocks, schists, limestones, graphitic shales, and slates. Richtofen found syenite containing both orthoclase and oligoclase, mica, and epidote, but no quartz. North and South of the syenite are metamorphic rocks, classed by Professor Whitney as Triassic. Over-lying the metamorphic is quartzose-porphyry. The foregoing are the oldest series. Propylite and Sanidin-Trachyte are of the Tertiary series.*

Church summarizes nine epochs during the structure as follows: (1) The Diorite, (2) the sub-ordinate pressure, (3) the Propylite, (4) the principal elevation, (5) the Andesite, (6) the opening of the Strata, (7) the Siliceous, (8) the Trachyte, (9) the Argentiferous. He claims that nothing like a real vein exists, and that the largest ore bodies can have been formed from deep mineral sources by the quiet action of the dynamic forces that have everywhere molded the earth's crust.

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*He says that propylite "incloses several, perhaps most, of the largest and most productive silver veins in the world, as those in the Karpathian Mountains, of Zacatecas and other places in Mexico, and probably several veins in Bolivia."

The following has been given for the succession of the Washoe Rocks:*

Becker.†	King.	Richthofen.
Granite	Granite and Syenite	Syenite.
Metamorphics		Metamorphics.
Granular diorites	Propylite or trachytic greenstone	Propylite.
Porphyritic diorites		
Quartz-porphyry		
Earlier Diabase		
Later Diabase ("black dike")		
Earlier hornblende-andesite	Earlier andesite	
Augite-andesite		
Later hornblende-andesite	Later andesite	
	Sanidin-trachyte	Sanidin-trachyte.
Basalt	Basalt	Other volcanic rocks.

† Mr. Becker particularizes as follows:
Granite = a pre-Tertiary, non-vitreous crystalline rock.
Diorite = a pre-Tertiary, non-vitreous crystalline rock.
Quartz-porphyry = a pre-Tertiary, glass-bearing porphyritic rock.
Diabase = a pre-Tertiary, more or less porphyritic rock.
Andesite = a Tertiary or post-Tertiary, glass-bearing, more or less porphyritic rock.
Basalt = a Tertiary or post-Tertiary, plagioclase, augite rock.

Mr. Church looks upon the vein as a substituted mass. There is a series of stratified eruptive rock 12,000 feet thick, in which lie a number of large quartz masses. Herein may be ore bodies imbedded which show no traces of existence at the present level of erosion. He considers that there were two periods of deposition.

Mr. Becker refers the present detailed structure of the country to faulting and not to eruptive bedding. The presence of faulting is recognized by irregular vein openings, horses, crushed condition of the quartz, slickensides, and rolled pebbles. He mentions an upward movement of the foot-wall, and finds the country rock, east and west, divided in sheets. All the large and profitable ore bodies have occurred at or near the west wall.

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* Mr. Becker determines the greater part of the hanging-wall to be diabase, and the "black-dike" also, and the supposed trachyte to be a hornblende-andesite. The so-called propylite, he states, comprises a number of Tertiary and pre-Tertiary rocks altered by decomposition.

Mining began in 1859. There had been extracted for the twenty-one years ending June 30, 1880, $306,000,000 in bullion, of which $132,000,000 was gold. The mines are the deepest in America. In 1882 there were 185 miles of galleries.

The lode itself is a long and wide belt of vein-matter, ramifying at each end into divergent angles. The foot-wall dips from 33° to 45° eastward. The claims extend about 22,000 feet north and south. The best mines so far opened are confined to about 12,000 feet. The east and west extension of rocks in which mineral has been found exceeds 15,000 feet. Mr. Becker gives cross-sections through the Utah, Union Shaft, C. & C., Hale & Norcross, and Belcher, showing the vein-matter between the earlier diabase at the east and Granular diorite at the west. The Sierra Nevada is put entirely in the diorite, while the Yellow Jacket shows slates at the west in place of the diorite. Mr. King shows the Yellow Jacket, Savage, and Crown Point quartz entirely in prophylite, while for the Hale & Norcross, Mexican, and Potosi syenite is shown at the west of the vein. Mr. Becker, in the Sutro Tunnel cross-section, gives from west to east as follows: (1) Granular diorite, (2) earlier diabase, (3) earlier hornblende-andesite, (4) augite-andesite, and (5) later hornblende-andesite. Large horses occur at upper levels and to a depth of 2,000 feet. The vein material, like most of the silver-bearing ores at the west, consists of a quartz gangue. In it are found native gold and silver, argentite (silver glance), polybasite, and stephanite, with some very rich galena and occasionally pyrargyrite, as also iron and copper pyrites, oxide of iron, manganese, sulphate of lime and magnesia, and carbonate of magnesia, lime, lead, and copper. The line of oxidation is confined principally to 500 feet in depth. The decomposition from metamorphic action increases with the depth, and is coincident with the faulting action and deposition of the ore.

The most probable view of the ore concentration attributes the bulk to deep-seated solfataric action, with accessions by lateral secretion to some extent from the east country. In a dry hole of the new Yellow Jacket shaft, with a self-registering thermometer buried in the rock, the temperature was 155° Fahr. at depth of 2,670 feet (3,103 feet below datum at Gould & Curry croppings) on July 10, 1879. Heated air and water are the greatest obstacle to mining. Observation has shown a somewhat arbitrary rate of increase of rock temperature of 1° Fahr. for each 33 feet. The greatest heat occurs in moist rock. The Gold Hill mines were flooded in 1880–'81 with water at temperature 170°.* The heat is found to decrease in a geometrical ratio horizontally eastward from the lode. Various theories have been propounded to account for the heat found in the rock and water of the chambers and drifts mined. These are (1) radiation from a melted or hot interior (igneous), (2) from deep waters, (3) oxidation of certain elements. Probably a combination of the second and third more reasonably explain the heat phenomena, which acts also upon the meteoric waters. The evidence of an uniform increase of temperature in rocks of the earth's crust thus far pierced are variable and conflicting. Too often, as at the Comstock, the chances are that the locality is an exceptional one, not promising uniformity. Therefore, while theoretically the greater depths will be hotter, still the ratio of increase is unknown. Doubtless a boring reaching below the action of deep waters would register a decrease in temperature.

The air passing through the openings (1882) was estimated at 300,000 cubic feet per minute. There were then never less than 1,000 men underground. Although there were double gangs for the eight-hour shifts, alternating every hour, requiring an unlimited amount of ice-water for drinking and washing in this permanently vitiated Russian or Turkish bath (according as air-space is wet or dry), yet all the miners were healthy. The sticks used in timbering are sawn square, 12 by 12 inches, fitted at the surface, and placed without nails. Up to 1880 it was estimated that 450,000,000 board feet had been consumed, together with about 900,000 cords of fuel for hoisting and pumping from 1860 to 1880, and about the same at the mills.

Changes in machinery up to 1879 are found noted on page 16 of Church's quarto volume.

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*Great bodies of very hot water in some of the principal mines has, for the present, substantially stopped deeper mining (say below 3,250 feet), thus limiting exploitation to the higher levels, larger lateral expansion, and among the low-grade ores.

The ventilation is by a combination of natural and artificial means. The former consists of the down and up cast shafts; the latter in local movements of air from one part of a mine to another by small engines. Air is also forced from the surface in some cases. The drifts and newly-opened spaces are fed by fan-blowers (compression instead of exhaustion) from air taken from the most favorable point of supply at one of the upper levels. All of these combined are scarcely adequate. Heavy machinery for pumping (capacity as high as 10,000,000 gallons per month) is an essential as a safeguard against "water bonanzas" or floods that do or may occur.

Mr. Church divides the ground of the main lode into wet and dry portions, the latter much in excess. The wet ground is fissured and decomposed. In thirty months there had been pumped 450,000,000 gallons (1,800,000 tons) of water from the Savage and Hale and Norcross. This "water bonanza" filled to the level of 1,750 feet, which was lowered only 250 feet at the end of three years. The Sutro Tunnel (1879) discharged 1,250,000 gallons daily.

A system of pan-amalgamation, with the aid of "bluestone" (cupreous sulphate) and salt, guaranties an average of 75 per cent. of the bullion from the ore. The relative yield of gold and silver is variable, having been 57 per cent. silver and 43 per cent. gold up to June 30, 1880. It is believed that the downward search will develop the existence of a more regular and deep-seated fissure.

It has been observed that ore bodies more frequently occur in the steeper parts of the dip, and that the thickest part of the quartz lies on the edge of the hollow of the west wall.

The obstacles to continued deep mining are temperature and drainage. The depth to which it is carried on account of the former is indeterminate. Mr. Becker says the boiling point of water at this level will be reached near 4,000 feet. Mr. Church estimates 201½° Fahr. for 4,000 feet and 273° Fahr. for 6,000 feet. These estimates are largely theoretical. The mines are now worked far below the level of the Carson River; therefore the engineering feat of hoisting the water may at deeper levels be enlarged and complicated by the presence of very hot and very large "water bonanzas." Mr. Becker thinks the prospects for ore are good while the hanging-wall shows diabase in mass.

The search should also be made eastward and westward. Nothing but a systematic exploration of the whole volcanic mass, 12,000 feet wide and 22,000 feet in length, to the greatest practicable depth, is adequate for the proper exploitation of this great mining region. A combination of the properties near the Sutro Tunnel with this latter enterprise would permit of more systematic and thorough opening and testing at a more reasonable expense, and of hoisting from chambers on this level.

Electrical observations as to the potentials of different parts of the lode were made by Mr. Becker with negative results.*

The regular atlas sheets and other maps issued by the Survey are included under the following heads: (1) Topographic atlas; (2) Geologic atlas and land classification series; (4) special maps separate from reports; (5) special maps accompanying and bound with reports; (6) miscellaneous.

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*The contour map was prepared as the basis of an extended survey and research into the physical structure and surroundings of this mineral deposit that has thus far rivaled in output any other district of our country. This examination, after the requisite mathematical surveys, above and below ground, needed to show the anatomy of the surface, the location of properties, the workings, and rock structure, was to have included a geological and mineralogical exposition of the whole region, including chemical, microscopical, and other examinations in petrography, together with the physics of the main vein and ore deposition as a whole, the mining, milling, machinery, shafting, timbering, pumping, ventilation, drainage, the Sutro Tunnel (its value and uses), the heat (rock, air, and water), air volumes and velocities, rock and other collections, effects of hot water, electrical conditions, the bonanza and borrasca, the probabilities in depth, and any and all observations suggested during the investigation, to the end that a type of its kind should result, giving data for all future engineering calculations and for a detailed relief model. Circumstances prevented the prosecution of this comprehensive work to its close.

The following published reports bear on this subject:

The Comstock Lode, by F. Baron von Richtofen, Ph. D. (November 22, 1865)—San Francisco, by the Sutro Tunnel Company: Towne & Bacon printers, 1866. 83 pp. 8°.

Vol. III, Reports of Geological Exploration of Fortieth Parallel, with Atlas—Washington: Government Printing Office, 1870. Mining Industry, by James D. Hague, with geologic contributions by Clarence King.

Reference to the structure and constituents of the Washoe Rocks are found in Vols. I and VI of the above reports.

Generally in the following annual reports of the U. S. Geographical Survey: Annual Report 1877, p. 1246; Annual Report 1878, p. 79; Annual Report 1879, p. 137; Annual Report 1878, Appendix H. Report upon examinations at the Comstock Lode, by John A. Church. pp. 145–166.

The Comstock Lode, its formation and history, by John A. Church, E. M., Ph. D.—New York: John Wiley & Sons, 1879. 4°. pp. 226.

U. S. Geological Survey, Monographs, Vol. III, Geology of the Comstock Lode and the Washoe District, with Atlas, by George F. Becker—Washington: Government Printing Office, 1882. 4°. pp. 422.

U. S. Geological Survey, Monographs, Vol. IV, Comstock Mining and Mines, by Eliot Lord—Washington: Government Printing Office, 1883. 4°. pp. 451.

Official reports by Mr. J. Ross Browne and Mr. R. W. Raymond, U. S. Mining Commissioners, by Mr. R. H. Stretch and other State mineralogists of Nevada, bearing on the economy and engineering of the mines, have been published.

The topographic sheets are intended to show all prominent features, natural or artificial, of the areas represented, with detail commensurate with the publication scale employed. These topographic sheets form the basis of the geologic and land classification series. The boundaries and relative positions of the atlas maps are shown upon the progress sheets found bound in the several annual reports.

The full sheets are published on the scale of 1 inch to 8 miles, or 1: 506880; the quarter sheets, to the scale 1 inch to 4 miles or 1: 203440; and special maps upon such other scales as the character of the area and the object to be subserved have demanded.

The originals are a series of plotting sheets usually on a scale of 1 inch to 2 miles, while the regular form of final issue is a photolithograph therefrom, principally in hachures, printed in black with an overlying flat tint, the dimensions of each sheet being 19 by 24 inches. Departure from this form of publication for advance issues and other reasons is specially noted. (See generally "List of Reports and Maps 1881," and pp. 71 and 74 for special and miscellaneous.)

The frontispiece sheets of the topographic atlas are as follows: Title, legend, sheet of conventional signs, progress and index map, and map of areas of drainage. Those preliminary to the regular geologic sheets are title and index map.

The geological formations exposed are indicated by colors according to a key or legend in the margin of each published sheet. They have been issued as lithographs with mountain reliefs in crayon and as photolithographs with hill shading in hachures.

The land classification series consists of certain maps of the topographic atlas, showing in colors, according to a key on the margin, approximately the areas of agricultural, grazing, timber, and arid or barren lands.

APPENDIX C.

METHODS OF SURVEY.

INTRODUCTORY.

A brief description of the methods of field observation, and subsequent office reduction, such as have been perfected and practiced, with examples in the astronomic, base measurement, geodetic, trigonometric, topographic, hypsometric, and map-making processes is herewith presented, together with a statement as to the instruments employed and computations practiced by the survey.

Incidentally allusion will be made to the investigations into the special subjects of Geology, Mineralogy, Paleontology, Zoology, Botany, Archæology, Ethnology, etc. Most of the forms (exceeding forty) for field and office work are the result of the special experience of the survey, and have largely been originated by the officer in charge to meet the requirements of rapid and extended topographic work, based on a computed triangulation with resultant maps, usefully, economically, and rapidly produced.

The problem presented upon being charged with explorations and surveys in the interior was to prosecute the grade of field observations commensurate with the rapid production of accurate topographic maps, useful in military operations and administration, over vast areas west of the Mississippi, at a minimum of time and cost.

The outgrowth of this requirement led to the framing and perfecting of a system of survey, based on a mathematically connected net-work of established points, which, except for suspension of appropriations, would have been carried to the completion of the first general survey of this region within the limits affixed, and would have given to the Government the nucleus of a skilled body of men, most valuable to a regular topographic and geographic office, filling a permanent requirement of the War Department.

Statistics show that for the whole world in 1885 an area of about 50,000,000 square miles was not undergoing a systematic instrumental topographic survey, as compared with 6,000,000 square miles (approximate) so surveyed at that date. (See p. 146, House Ex. Doc. 270, Forty-eighth Congress, second session.) Hence it would appear that the system of work pursued so economically and effectively will have its further application in portions of the above immense area, prior to the ultimate requirement for a more elaborate, detailed, and expensive general survey.

On our own continent there is a field for the development, to completion, of such surveys in the mountainous territory west of the one hundreth meridian, in Alaska, the more temperate part of Canada, and parts of Mexico (except for the more thickly settled portions), in the Central American States, and the same is true for all of South America. On the other hand, it may be remarked that in general, the United States surveys conducted east of the Mississippi should be based on trigonometric points established with the greatest accuracy, and with all known scientific refinements, while such purely topographic details only as are required by the scale of map temporarily published may be varied considerably.

All other grades of work, inferior in plan or grade of result, are but temporary expedients.

The projection and scale upon which the map is to be made having been determined, geographic points, the co-ordinates of which are necessary as a basis for its construction, are obtained by means of astronomic, geodetic, topographic, and hypsometric observations. The classes of points employed in the horizontal projection of the main objects observed are: (1) Main astronomic, (2) secondary astronomic, (3) sextant latitude, (4) base-line, (5) main triangulation, (6) secondary triangulation, (7) cross-sight, (8) three-point, and (9) meander, each and every one of which become a topographic station. The determinations for altitude result from barometric observations and from angles of elevation and depression. The initial points to which the geodetic and topographic determinations are referred, and by which checked, are established at the main and secondary astronomical stations. The sextant latitude stations check a special class of points on extended meanders. The number of main and secondary astronomically determined points required for checks over the entire area is comparatively few. The probable error of the resulting longitudes and latitudes is a minimum for the class of instruments and observations employed.

FIELD.

MAIN ASTRONOMICAL STATIONS

The main astronomical stations, selected upon or at the termini of telegraph lines, and at intervals of from 250 to 300 miles, checking belts of triangles, are occupied with the best field astronomical instruments, the comparison of times being made by telegraphic exchanges. Near each point a base is laid out, measured and connected therewith, and observations made at the vertices of triangles so disposed as to completely envelop the base and initial astronomical point, and to furnish computed bases to which the main triangulation stations next adjacent can readily be referred The observations taken at the vertices of the triangles surrounding the base are similar in number and accuracy to those at main triangulation stations, and one initial point answers for each and all of the belts of triangles centering at a single base. The set of instruments and apparatus used at a main astronomical station are one combined meridian transit of 26 or 30 inch focal length, with appurtenances, or

1 astronomical transit, and
1 zenith telescope.
1 astronomical clock or break-circuit chronometer.
1 chronograph, and
1 personal equation apparatus.
1 connecting switch-board.
2 break-circuit keys.
1 battery of two jars, insulated connecting-wire, and battery fluid.
150 yards extra telegraph wire.
1 observing-tent, and the usual meteorological instruments, hereafter mentioned.

The observations are generally made from a brick pier surmounted by a stone slab, upon which the base of the instrument rests. This observing-pier acts as a permanent monument marking the spot, and may be available at a subsequent period for other astronomical observations.

The meridian is marked by north and south piers of stone, securely planted at conspicuous localities. The monument and meridian marks fix upon the ground a line, the length and true azimuth of which become known with much accuracy.

An hourly series of meteorological observations, including as long an interval as possible, is made at each main station.

The method of making and recording the observations for time and latitude, exchanging signals, computing results, and placing the same in form for publication, is shown in Vol. II of the quarto reports.* The mean probable error at twenty stations, at which there is an average number of determinations of longitude of at least five, is found to be ±0″.27, and at the same stations, with an average number of determinations of latitude of at least one hundred and thirty-five, there appears a mean probable error of ±0″.08.

An apparatus for determining absolute personal equation, invented and designed by Dr. Kampf, in association with myself, in the winter of 1873–'74, will be found figured as Plate III, appendix, page 475, and described on pages 482, 483 of Vol. II, Astronomy. The principle of the mechanism consists in producing a point of light, which serves as a star, the actual time of passage of which over ruled lines making a reticule is automatically recorded on the chronograph, and with which the recorded time of passage noted by the observer is compared, which thus may be made to eliminate the "personal equation."

It is believed that this arrangement works perfectly automatically, and upon making the changes suggested on page 483, Vol. II, will prove entirely satisfactory, being simple, effective, and comparatively inexpensive.

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* The order of sequence for an astronomic report is given on p. 3, Vol. II, and instructions for conducting latitude and longitude determinations appears on p. 80 *et seq*, special Astronomical Report, 1874, while the manual for these and all other field observations remains in manuscript incomplete. A preliminary pamphlet of "Instructions for officers and civilian assistants" was issued in 1874.

SECONDARY ASTRONOMICAL STATIONS.*

These differ from the main stations more particularly in the lesser accuracy with which time and latitude are determined. The instruments used are the sextant and artificial horizon, with a mean solar or sidereal box or pocket chronometer. The observations are wholly by eye and ear. The exchanges, instead of by automatic signals, are arbitrarily selected and transmitted by the observers at the sending and receiving stations. An illustration of the manner of conducting observations at one of the stations, although still subject to improvement, is shown in the Preliminary Report of the Reconnaissance of 1869. This class of observations may be availed of at stations far distant from railroad communication, thereby saving time and expense and the endangering of instruments by their transportation in rude vehicles over rough roads for long distances in the interior. The observations for time and latitude are similar in every respect to those employed in latitude observations, except that more weight is attached to the time determinations, and the number of sets of observations is multiplied and extended over a longer interval. The usual meteorological observations are made, and it is often found practicable to prosecute an hourly series of these at secondary astronomical stations. The point of observation is usually marked by a strong stone pier. The reductions are the same as those given in the next heading, and the probable error of time determinations and the resulting comparisons may or may not be determined by the aid of "least squares."

SEXTANT LATITUDE STATIONS.*

Points are checked in latitude and approximately in longitude by sextant observations for time and latitude along measured lines that traverse long cañons, mountain defiles, or low valleys and ravines, that admit of but few three-point stations, the horizon of distant elevated points being intercepted by intervening obstacles. Observations of this grade are made at most of the camps occupied while surveying a given region. The instruments used are a sextant, with an artificial horizon, a mean solar or sidereal box or pocket chronometer. The usual meteorological observations are made during the interval. The local time is determined by sets of observations of single or double altitudes of the sun, or certain selected east and west stars. The latitude results from sets of circummeridian altitudes of selected south stars and altitudes of Polaris, arbitrarily selected. For each set of south-star observations a corresponding set of Polaris observations is required, and the same for the meridian altitudes of the sun. The record forms required for observations and computations are: (1) sextant observations; (2) time by single altitudes; (3) time by equal altitudes; (4) latitude by Polaris; (5) latitude by circummeridian altitudes. The probable error of a mean latitude as determined from two sets of south star and three sets of Polaris observations $= \pm 1''.45$. (See Preliminary Report of 1869, p. 35.)

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* Both the "secondary" and "sextant" stations above described were not found necessary to any appreciable extent, except in the earlier field years, when telegraph stations were few and far distant, and the trigonometric nets had been only partially developed.

The following are examples of forms for field astronomic observations (time by astronomic transit, and latitude by zenith telescope): (*a*) Abbreviations and signs; (*b*) time observations; (*c*) signals; (*d*) mean places of stars; (*e*) setting list; (*f*) observations for latitude (time and latitude by sextant and chronometer); (*g*) finding list; (*h*) sextant observations.

(*a*)—ABBREVIATIONS AND SIGNS.

$a.\ b.\ c.$ = azimuth, level, and collimation corrections.

A. B. C. = azimuth, level, and collimation factors.

T = observed time, reduced to the mean of wires and corrected for rate.

T' = observed time, corrected for instrumental errors.

Æ = apparent right ascension of star.

$\Delta_0 T$ = resulting error of the chronometer after the mean of the wires is corrected for rate and level.

ΔT_0 = adopted mean error of chronometer.

$\delta T = \Delta T_0 - \Delta_0 T.$

ΔT = error of the chronometer.

v = difference between mean final correction of chronometer and ΔT.

(5)—TIME OBSERVATIONS.

Station, Colorado Springs, Colo. August 9, 1873. Dr. F. Kampf, observer. Chronometer No. 1491, Negus sidereal.

Object	α Coronæ.	β Scorpii.	δ Ophiuchi.	τ Herculis.	η Draconis.
Illum. and description	East.	East.	East.	East.	East.
Factor A	(Azimuth) 0.20	0.92	0.67	−0.20	−0.88
B	(Level) 1.18	0.87	0.74	1.44	1.06
C	(Collimation) 1.13	1.00	1.00	1.66	2.13
Levels	26.0 29.2	....	E. 26.7 W. 28.4	28.5 29.2	28.5 27.0
Do	29.5 26.0	....	26.5 28.0	29.2 27.7	27.3 28.6
Sums (b)	+0s.02	+0.01	0s.00	+0s.03	−0s.004
Threads 1	16 2 13.90	16 8 1.71	16 17 41.18	16 25 48.05	16 21 50.90
2	22.50	6.20	45.20	54.73	22 8.20
3	31.60	14.70	....	26 6.20	25.83
4	30.23	19.88	57.70	12.71	34.00
5	41.40	24.10	18 2.26	19.15	44.20
6	50.58	28.15	10.83	31.30	23 01.67
7	55.97	37.77	15.00	37.00	10.26
Means	16 2 36.71	16 8 18.87	16 17 58.00	16 26 12.94	16 22 34.05
Transit mean thread	....	....	− 0.73	....	....
Correction for level	+ 0.02	+ 0.01	0.00	+ 0.06	− 0.01
Correction for collimation	+ 0.06	+ 0.07	+ 0.07	+ 0.10	+ 0.16
Correction for azimuth	+ 0.25	+ 0.80	+ 0.73	− 0.22	− 0.60
Reduced transit	16 2 37.06	16 8 20.04	16 17 58.73	16 26 12.88	16 22 34.07
Tabular A. R.	15 52 21.37	15 58 4.88	16 7 43.10	16 15 58.96	16 12 18.42
Error of chronometer—fast	10 15.69	10 15.72	10 15.60	10 13.90	10 15.94

Object	A Draconis.	η Herculis.	α Ophiuchi.	ε Ursæ Min.	σ Herculis.	44 Ophiuchi.
Illum. and description	East.	West.	West.	West.	West.	West.
Factor A	−1.41	−0.01	0.50	−4.00	0.42	0.92
B	2.42	1.29	0.80	5.28	0.95	0.90
C	2.50	1.30	1.01	7.41	1.04	1.00
Levels	....	27.0 29.5	27.5 29.2	23.0 29.5	....	28.5 30.0
Do	....	27.6 29.3	27.0 29.4	27.3 29.5	....	28.5 31.5
Sums (b)	+0s.06	+0s.07	+0s.05	+0s.06	+0s.06	+0s.07
Threads 1	16 37 46.90	16 45 27.90	17 1 38.00	17 7 22.35	17 18 51.87	17 28 35.37
2	56.38	32.50	42.86	55.80	55.30	40.00
3	38 20.25	44.40	52.06	8 57.34	19 4.18	46.21
4	33.04	50.30	58.88	9 30.42	8.61	54.10
5	45.20	55.76	2 0.90	10 2.30	15.29	56.91
6	39 8.97	46 6.13	9.18	11 8.40	21.00	29 7.00
7	21.70	11.80	12.40	34.35	25.78	12.41
Means	16 38 30.05	16 45 49.92	17 1 56.26	17 9 20.77	17 19 8.08	17 28 52.97
Cor. for level	+ 0.12	+ 0.09	+ 0.04	+ 0.27	+ 0.05	+ 0.08
Cor. for collimation	+ 0.16	− 0.06	− 0.07	− 0.30	− 0.07	− 0.07
Cor. for azimuth	− 1.08	− 0.01	+ 0.64	− 5.47	+ 0.45	+ 1.06
Reduced transit	16 38 32.45	16 45 49.88	17 1 56.86	17 9 13.67	17 19 9.11	17 28 54.03
Tabular A. R.	16 28 16.02	16 35 34.26	16 51 41.15	16 59 7.02	17 8 53.25	17 18 38.13
Error of chron.—fast	10 15.82	10 15.67	10 15.40	10 15.74	10 15.80	10 15.85

a = +1.075. Mean correction of chronometer −10m 15s.745.
c = +0.067. for 16h 20m ± 0.018.

(c)—LONGITUDE OBSERVATIONS—ARBITRARY SIGNALS SENT AND RECEIVED.

Station, Colorado Springs, Colo. August 2, 1873. Sent from Salt Lake City, Utah. Sent from Colorado Springs, Colo.

	Sidereal chronometer 1491. Colorado Springs.	Sidereal chronometer 1511. Salt Lake City.	Sidereal chronometer 1491. Colorado Springs.	Sidereal chronometer 1511. Salt Lake City.	Remarks by observer.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	
	18 37 37.98	9 51 59.00	18 42 55.36	9 57 16.90	The seconds from the Salt Lake City chronometer coincide with those of my own. I got four full minutes, and find that my seconds come $0^{s}.095$ later than Clark's. This number has to be subtracted from all signals received and given as Colorado Springs chronometer, and from the mean.
	47.81	52 8.81	43 5.52	26.99	
	37 57.47	18.47	15.60	36.93	
	38 7.46	28.44	26.12	47.88	
	17.85	38.54	36.50	57 57.91	
	27.50	48.00	46.49	58 7.90	
	38.00	52 58.01	43 55.64	16.67	
	47.79	53 8.79	44 5.60	26.95	
	38 57.51	18.50	16.40	37.71	
	39 7.64	28.65	25.60	46.90	
	17.97	38.55	35.60	58 56.90	
	27.90	48.90	45.56	59 6.96	
	37.64	53 58.06	44 55.53	16.67	
	47.80	54 8.90	45 5.50	26.82	
	39 57.90	18.90	15.53	36.80	
	40 7.97	29.00	25.50	46.67	
	17.81	38.83	35.37	9 59 56.85	
	27.90	48.90	45.50	10 0 6.96	
	18 40 38.00	9 54 58.90	18 45 55.56	10 0 16.90	
Means..	18 39 7.721	9 53 28.720	18 44 25.914	9 58 47.234	
	−0.095				
	18 39 7.626				

CHRONOMETER CORRECTION.

	Determined by set of stars.	Sidereal hour.	Chronometer correction.	Hourly rate.
1873.		h. m.	m. s.	
Aug. 2	Before exchange of time signals..	16 35	−10 15.745	$-0^{s}.1017$
Aug. 2	After exchange of time signals...	19 29	−10 16.036	

(d)—MEAN PLACES OF STARS FOR 1873.

[Used for determination of latitude of Colorado Springs, Colo.]

Number of pair.	Number in B. A. C.	Right ascension.			Declination.			Number of pair.	Number in B. A. C.	Right ascension.			Declination.		
		h.	m.	s.	°	'	"			h.	m.	s.	°	'	"
1	5587	16	34	37	12	35	35.4	23	7140	20	32	51	30	45	33.4
	5626	16	40	03	64	49	48.4		7189	20	39	06	56	55	44.74
2	5747	16	56	55	35	46	14.08	24	7243	20	45	37	50	19	41.56
	5775	17	01	13	43	00	09.46		7256	20	49	06	27	34	23.08
3	5790	17	03	33	40	49	59.06	25	7297	20	55	05	30	45	33.06
	5834	17	10	38	36	57	13.04		7329	20	58	00	33	00	33.70
4	5871	17	16	46	40	21	56.56	26	7361	21	06	13	22	33	46.3
	5927	17	26	07	31	15	15.10		7401	21	13	37	55	15	54.43
5	5978	17	33	41	61	58	18.9	27	7444	21	18	53	35	37	43.49
	5991	17	36	16	16	00	44.7		7489	21	27	11	52	03	36.39
	6079	17	51	29	56	53	35.36	28	7505	21	29	35	37	07	36.33
6	6110	17	56	37	29	30	06.7		7531	21	31	03	30	50	37.76
7	6157	18	03	30	20	47	46.3	29	7554	21	36	38	40	13	45.02
8	6238	18	15	04	28	46	39.4		7596	21	38	10	37	43	10.93
	6255	18	19	18	40	03	38.30	30	7621	21	46	12	06	13	06.4
9	6357	18	33	55	30	33	30.29		7641	21	50	45	11	36	37.5
	6385	18	35	54	38	15	01.54	31	7683	21	57	48	07	33	17,18
10	6391	18	40	14	30	26	51.50		7733	22	04	30	30	21	18.4
11	6468	18	50	13	33	48	37.33	32	7757	22	07	50	37	58	46.49
	6475	18	51	26	43	46	47.30		7825	22	20	17	40	46	35.33
12	6536	18	57	51	46	45	30.86		7832	22	22	17	—0	40	00.8
	6571	19	06	54	31	04	23.43	33	7857	22	26	44	78	08	15.1
13	6596	19	09	17	65	46	57.5	34	7874	22	28	44	78	10	19.9
	6615	19	13	44	12	06	35.4		7890	22	30	13	56	56	30.63
14	6652	19	19	49	30	01	31.6	35	Gr. 3878	22	30	06	36	33	07.36
	6681	19	23	29	57	46	18.90		7931	22	33	21	36	48	01.06
15	6698	19	27	03	34	11	03.23	36	7951	22	41	18	—4	53	13.7
	6720	19	30	43	43	40	03.88		7996	22	47	55	33	38	47.5
16	6731	19	32	42	44	24	56.30		8065	23	03	51	11	06	03.8
	6784	19	41	36	33	36	00.74	37	8089	23	06	43	06	31	30.0
17	6819	19	46	42	16	20	40.49	38	8077	23	04	56	06	33	00.5
	6852	19	51	19	50	23	38.26		8147	23	16	36	19	51	47.4
18	6883	19	53	51	57	54	38.94	39	8186	23	24	11	57	50	05.96
	6901	19	56	31	19	37	42.0	40	Gr. 4110	23	33	21	57	57	05.56
19	6918	20	01	40	51	28	32.36		8296	23	45	57	30	37	54.32
	6944	20	08	41	28	06	03.7	41	8310	23	48	03	36	47	36.04
20	6962	20	09	28	42	30	40.53	42	8317	23	49	13	56	43	13.74
	6990	20	13	46	34	36	13.28	43	Gr. 4318	23	57	30	40	00	47.30
									8374	0	00	01	36	19	13.15
21	7022	20	17	40	30	01	04.58	44	28	0	06	55	60	37	08.30
	7051	20	23	52	33	01	27.96		67	0	14	36	37	15	33.05
22	7084	20	26	10	36	30	32.70	45	87	0	15	54	1	14	10.00
	7101	20	28	39	41	03	34.58		105	0	23	46	76	10	06.8

(e)—ZENITH TELESCOPE SETTING LIST.

Station, Colorado Springs, Colo. Approximate latitude, 38° 49′.7. Approximate longitude, 6h 59m 17s.

No. pair.	B. A. C.	Mag.	α			δ		Zenith distance.		S. N.	Setting.		Remarks.
			h.	m.	s.	°	′	°	′		°	′	
1	5567	6½	16	34	57	12	38.6	26	11.1	S.	26	5.6	
	5628	5		40	3	64	49.8	26	0.1	N.			
2	5747	5	16	56	55	33	45.2	5	4.5	S.	5	7.0	
	5775	6	17	1	13	43	59.2	5	9.5	N.			
3	5790	5½	17	3	26	40	41.0	1	51.3	N.	1	51.9	
	5834	3½		10	35	36	57.2	1	52.5	S.			π Herculis.
4	5871	6		16	46	46	22.0	7	32.3	N.	7	33.4	
	5927			25	7	31	15.2	7	34.5	S.			
5	5978	6		33	41	61	58.3	23	8.6	N.	22	58.8	
	5991	6		36	10	16	0.7	22	49.0	S.			
	6079	3½		51	20	56	52.6	18	2.9	N.	18	1.3	ξ Draconis.
6	6110	5		56	57	20	50.1	17	59.6	S.			
7	6157	5½	18	2	20	20	47.8	18	1.9	S.			
8	6238	6		16	4	28	48.6	10	1.1	S.	10	7.4	υ Herculis.
	6255	5		18	18	49	2.5	10	12.8	N.			
9	6357	6		33	56	39	33.4	0	43.7	N.	0	39.2	
	6365	6		35	54	38	15.0	0	34.7	S.			
10	6391	5		40	16	39	29.8	0	40.1	N.			ε² Lyræ.
11	6466	6		50	13	33	48.4	5	1.3	S.	4	0.7	
	6475	5		51	28	43	46.8	4	57.1	N.			
12	6520	5½		57	51	46	45.3	7	55.6	N.	7	50.5	
	6571	6	19	6	54	31	4.4	7	45.3	S.			
13	6580	6		9	17	65	45.9	26	56.2	N.	26	48.7	
	6615	6		13	46	12	8.6	26	41.1	S.			δ Aquilæ.
14	6652	7		19	40	20	1.4	18	48.3	S.	18	52.5	
	6681	6½		23	29	57	46.3	18	56.6	N.			
15	6696	6		27	3	34	11.1	4	38.6	S.	4	44.5	
	6720	6		30	43	43	40.0	4	50.3	N.			
16	6731	6		33	42	44	24.9	5	35.2	N.	5	29.5	
	6784	5		41	36	33	26.0	5	23.7	S.			χ Cygni.

(*f*).—OBSERVATIONS FOR LATITUDE.—COMPUTATION.

Station, Colorado Springs, Colo. August 2, 1873. Dr. F. Kampf, observer. Dr. F. Kampf, recorder.

No. of observation.	No. of pair.	No. in B. A. C.	N. S.	Micrometer reading.	Level.		Remarks.
					N.	S.	
				Turns. Divs.	*d.*	*d.*	
18	1	5587	S.	12 2.6	16.0	25.4	Air good, little undulating.
		5628	N.	2 82.9	45.5	Out.	
19	2	5747	S.	7 22.7	19.8	22.3	
		5775	N.	12 27.6	21.6	20.8	
20	3	5790	N.	8 79.0	21.3	20.7	
		5894	S.	9 79.8	14.3	27.9	
21	4	5871	N.	7 42.6	24.3	17.3	
		5927	S.	4 72.0	21.4	20.0	Wrong star. ?
22	5	5978	N.	16 82.0	22.3	19.6	
		5991	S.	−0 78.7	12.0	29.0	
		6079	N.	11 94.6	25.6	17.0	22^s after last wire.
23	6	6110	S.	7 6.9	9.3	32.0	
24	7	6157	S.	9 35.1	8.0	33.6	
25	8	6238	S.	2 62.8	24.0	17.7	
		6255	N.	15 0.7	8.3	33.4	
26	9	6287	N.	13 31.0	20.0	22.0	
		6365	S.	4 53.2	11.9	29.4	13^s after meridian; very faint.
27	10	6390	N.	8 25.0	23.0	19.3	
28	11	6468	S.	11 94.6	21.6	21.8	
		6475	N.	8 8.1	17.0	26.0	
29	12	6529	N.	14 20.0	24.4	18.7	
		6571	S.	4 26.4	9.3	33.4	
30	13	6598	N.	17 10.2	21.8	20.9	Changed the inclination on the last wire.
		6615	S.	2 31.3	28.9	19.5	

No. of observation.	Declination.	Half sum of declinations.	Corrections.			Latitude.
			Microm. and refr.	Level.	Merid.	
	° ′ ″	° ′ ″	′ ″	″	″	
18	12 38 36.28	38 44 17.10	+5 16.52	+8.83	0.00	38 49 42.45
	64 49 57.92					
19	33 56 19.77	38 53 18.27	−3 36.61	−0.27	0.00	38 49 41.39
	43 50 16.77					
20	40 41 6.67	38 49 12.95	+0 31.09	−3.56	0.00	38 49 40.48
	36 57 19.23					
22	61 58 27.07	38 59 37.08	−9 58.67	−3.63	0.00	38 49 34.78
	16 0 47.09					
	56 53 42.90					
23	20 50 9.14	38 51 56.02	−2 12.26	−4.03	+0.30	38 49 40.03
24	20 47 49.68	38 50 46.29	−1 1.99	−4.84	+0.30	38 49 39.76
25	28 48 44.07	38 55 9.43	−5 24.60	−5.14	0.00	38 49 39.69
	49 1 34.80					

(*f*).—OBSERVATIONS FOR LATITUDE.—COMPUTATION—Continued.

No. of observation.	Declination.	Half sum of declinations.	Corrections.			Latitude.
			Microm. and refr.	Level.	Merid.	
	° ′ ″	° ′ ″	′ ″	″	″	
26	39 33 31.90 38 15 7.04	38 54 19.47	−4 33.73	−5.36	+0.04	38 49 41.43
27	39 28 57.04	38 53 2.04	−3 17.35	−2.79	+0.04	38 49 41.94
28	33 48 32.34 43 46 52.49	38 47 42.42	+2 00.07	−2.69	0.00	38 49 39.80
29	46 45 30.13 31 4 27.16	38 54 58.64	−5 13.50	−5.06	0.00	38 49 40.08
30	65 46 2.57 12 8 38.79	38 57 20.68	−7 39.54	+1.73	+0.04	38 49 42.91

(*g*).—TIME STARS.

The following table gives the time stars which it will be most favorable to use, and they are paired generally in the most convenient manner for observing. If practicable, they should be observed at the same altitudes east and west; at any rate the altitudes should be as nearly equal as possible. The double altitudes should be between 80° and 120°, and, if practicable, the time observations should be made before and after the latitude observations.

Month.	East star.	West star.	Approx. double altitude.	East star.	West star.	Approx. double altitude.
June	α Lyræ	γ Ursæ Majoris	85°	α Cygni	α Coronæ Borealis	
July	α Lyræ	Arcturus	100°	α Cygni	α Coronæ Borealis	
August	α Cygni	Arcturus	118°	Markab	α Coronæ Borealis	95°
September	Markab	α Coronæ Borealis	90°	γ Pegasi	α Lyræ	
October	α Andromedæ	α Lyræ	110°	β Andromedæ	α Cygni	
November	β Arietis	Altair	88°	α Ceti	ε Pegasi	88°

The following gives, in the order of their Right Ascensions, a list of stars which may also be used for time when from any cause it is impracticable or undesirable to use the stars of the above list:

β Cassiopeæ.
δ Andromedæ.
α Cassiopeæ.
β Andromedæ.
ε Cassiopeæ.
β Arietis.
γ Andromedæ.
β Persei.
α Persei.
ε Ursæ Majoris.
η Ursæ Majoris.
α Serpentis.
β Serpentis.
β Herculis.
ζ Herculis.
ε Herculis.
β Draconis.
γ Draconis.
ζ Aquilæ.
β Cygni.
γ Aquilæ.
δ Cygni.
β Capricorni.
γ Cygni.
ε Cygni.
ζ Cygni.
ε Pegasi.
α Aquarii.
γ Pegasi.
β Pegasi.

SOUTH STARS.

[To be used for sextant latitude observations. The local mean times of culmination on meridian 116° west of Greenwich given.]

1878.

Star.	Day.	June.	Day.	July.	Day.	August.	Day.	September.	Day.	October.	Day.	November.
		h. m. s.		h. m. s.								
β Libræ.	1	10 29 53	1	8 31 37								
	5	10 14 07	5	8 15 51								
	10	9 54 24	10	7 56 08								
	15	9 34 41	15	7 36 25								
	20	9 14 58	20	7 16 42								
	25	8 55 15	25	6 56 59								
α Serpentis.	1	10 57 42	1	8 59 26								
	5	10 41 59	5	8 43 39								
	10	10 22 18	10	8 23 57								
	15	10 02 31	15	8 04 14								
	20	9 42 48	20	7 44 31								
	25	9 23 06	25	7 24 48		h. m. s.						
α Ophiuchi.			1	10 50 27	1	8 48 13						
			5	10 34 40	5	8 32 27						
			10	10 14 56	10	8 12 44						
			15	9 55 15	15	7 53 01						
			20	9 35 32	20	7 33 19						
			25	9 15 49	25	7 13 36		h. m. s.		h. m. s.		
Altair (α Aquilæ.)					1	11 03 46	1	9 01 32	1	7 03 16		
					5	10 47 59	5	8 45 46	5	6 47 29		
					10	10 28 16	10	8 26 03	10	6 27 47		
					15	10 08 34	15	8 06 20	15	6 08 04		
					20	9 48 51	20	7 46 37	20	5 48 21		
					25	9 29 08	25	7 26 54	25	5 28 38		h. m. s.
ε Pegasi.							1	10 54 55	1	8 56 38	1	6 54 25
							5	10 39 09	5	8 40 52	5	6 38 39
							10	10 19 26	10	8 21 10	10	6 18 56
							15	9 59 43	15	8 01 27	15	5 59 14
							20	9 40 01	20	7 41 44	20	5 39 31
							25	9 20 18	25	7 22 01	25	5 19 48
Markab. (α Pegasi.)									1	10 17 08	1	8 14 55
									5	10 01 22	5	7 59 09
									10	9 41 40	10	7 39 26
									15	9 21 57	15	7 19 44
									20	9 02 14	20	7 00 01
									25	8 42 31	25	6 40 18

Besides the above, which will always be used when possible, the following may be used for south-latitude stars. They are given in the order of their Right Ascensions:

α Libræ.
δ Serpentis.
γ Serpentis.
δ Ophiuchi.
ζ Ophiuchi.
α Capricorni.
β Capricorni.
β Aquarii.
α Aquarii.
γ Aquarii.

Polaris will always be observed as the North star for latitude.

(b).—SEXTANT ASTRONOMICAL OBSERVATIONS.

Sextant No. 6, and artificial horizon of Mercury. M. T. chronometer No. 1253, by Negus. Station: Camp 10, near Hamilton, Nev. Lieut. G. M. Wheeler, sextant observer.

Object observed: Sun's upper limb. Date: July 18, 1869.		Object observed: Sun's upper limb. Date: July 20, 1869.		
Time of observation by chronometer.	Observed double altitudes.	Time of observation by chronometer.	Observed double altitudes.	Time of observation by chronometer.
h. m. s.	° ′ ″	h. m. s.	° ′ ″	h. m. s.
9 26 57.0	114 00 00	9 32 53.0	113 10 00	1 41 54.5
9 27 27.2	114 10 00	9 33 23.5	113 20 00	1 41 24.2
9 27 55.0	114 20 00	9 33 50.5	113 30 00	1 40 53.8
9 28 25.3	114 30 00	9 34 21.5	113 40 00	1 40 24.0
9 28 51.8	114 40 00	9 34 50.0	113 50 00	1 39 55.0
9 29 21.0	114 50 00	9 35 19.0	114 00 00	1 39 26.0
9 29 49.4	115 00 00	9 35 49.5	114 10 00	1 38 56.5
9 30 22.0*	115 10 00	9 36 18.5	114 20 00	1 38 24.1
9 30 45.8	115 20 00	9 36 48.5	114 30 00	1 37 52.0
9 31 12.3	115 30 00	9 37 16.6	114 40 00	1 37 27.7
9 31 41.5	115 40 00	9 37 47.5	114 50 00	1 37 00.0
9 32 12.0	115 50 00	9 38 17.5	115 00 00	1 36 30.0
		9 38 47.0	115 10 00	1 36 00.5
Mean (12) 9 29 34.68	114 55 00	Mean (13) 9 35 49.22		1 38 56.56

Object observed: α Aquilæ (Altair). Date: July 28, 1869.		Object observed Polaris. Date: July 28, 1869.	
Time of observation by chronometer.	Observed double altitudes.	Time of observation by chronometer.	Observed double altitudes.
h. m. s.	° ′ ″	h. m. s.	° ′ ″
10 41 1	118 30 00	10 56 19.3	79 04 30
10 41 31	118 31 00	10 57 53	79 05 30
10 42 06.5	118 32 00	10 58 48.1	79 06 00
10 42 43	118 33 00	10 59 20	79 06 30
10 43 22.7	118 34 00	11 00 33.2	79 07 00
10 44 20.8	118 35 00	11 01 22	79 07 30
10 45 22	118 36 00	11 02 07	79 08 00
10 47 46	118 37 00	11 02 53.5	79 08 30
10 49 53	118 35 30	11 03 35.8	79 09 00
10 50 55	118 34 00	11 04 20	79 09 30
10 51 54	118 33 00	11 04 55	79 10 00
10 52 46	118 32 00		
10 53 34.8	118 31 00		
10 54 25	118 30 00		
10 55 10.1	118 29 00		
Mean (15)	118 32 50	Mean (11) 11 01 07.81	79 07 27.27

*Should be 17s.0 = ?

BASE MEASUREMENT.

The location of the base line is selected with great care, having in view the greatest level expanse conveniently situated as regards the initial geographic points and those intended to be occupied in the scheme of development.

The entire line is cleared of all impediments and made as level as possible.

The extremities are permanently marked by 5-foot iron rods encased in cement-laid brick piers, and iron bolts at intervals of 200 feet are placed for convenience and accuracy in alignment. The line is also accurately leveled. For the purpose of development large temporary wooden frames are erected over the ends of the line.

The measurements were made by a rod herein described.

DESCRIPTION OF MEASURING-ROD.

The rod was decided upon by the officer in charge in the winter of 1875–'76, upon consultation with Dr. Kampf, and constructed by Mr. Edward Kahler. It was made of wood, 20 feet in length, strengthened by vertical cross-piece. Each end of the rod is provided with a scale 8 inches long, subdivided to one one-hundreths of an inch so that by a magnifier it can be read to thousandths. At a point near the center an arc of a circle of 30° extension is fastened. An arm attached to the center of the circle, and movable by a micrometer screw, carries a level, so that after determining the zero point on the face of the circle the inclination of the rod can be easily read to five minutes. The rod is placed for measurement on two iron plates weighing about 30 pounds each, and provided with three strong iron pins 2 inches long. In the center of the plate, on an elevated silver plane, is drawn a cross-line, which acts in the nature of the zero-point of the line.

METHOD OF COMPARISON.

The rod was compared daily, both before and after its use, with two steel standard rods, constructed by the U. S. Coast Survey, and of a normal length of 5 feet, at the temperature of 61°.6 Fahr. A very simple apparatus was used, constructed for comparison, the standard steel rods being supported on two wooden blocks, and therefore elevated by the thickness of this support from the plane of measurement, two knife-blades were driven in a wooden board, 22 by 1½ feet by 4 inches, being as much above the surface of the board as the polished plane at the end of the normal rod. The center of the sharp blade and the plane of the normal rod are brought into the same vertical plane, and by an assistant is kept in this position until the second rod is brought in contact with the first. Thus continuing, the fourth rod was found to reach over the knife-blade about 1½ inches. A square block of wood was placed at the end, in contact with the normal rod, and by means of a small measure, 3 inches long, and divided to hundredths, the distance from the square block of wood to the blade of the knife is read, the temperature being always carefully noted and the measurement repeated.

After determining the distance between two points on the edges of the knife-blades, the measuring-rod is placed on top of the blades with the utmost care, and the scale on both ends read. In this manner the amount of overlapping of the rod was obtained.

DESCRIPTION OF METHOD OF MEASUREMENT.

The line is laid out in advance for one day's work, marked by iron pins 2 feet in length and about 180 feet apart. A fine line is tied to one pin and fastened to the next one. Two plates are then laid down within the distance of 20 feet 2 inches, approximately, so that they are parallel with the line and tangent to it. One laborer takes the measuring-rod, bringing it near the plates, and the assistant being at the rear end, the laborer on the other, both grasp the rod at the same time and put it on top of the plates five one-hundredths of an inch distant from the cross on the ridge of the plates. The assistant reads the rear end of the scales at the same time that the principal observer reads at the front end by means of a common magnifying-glass. The readings are then at once recorded. After that the level is read by the principal and simultaneously by the assistant, who is now at the front end. He reads the rear end of the scales, and the readings are recorded by both. Then the readings are called out and in case of disagreement repeated. In the mean while the other laborer puts an auxiliary rod of 20 feet 2 inches in the position, so that the rear end may be in line with the mark on the plate driving the third plate in the ground. When the readings are finished the new plate is found in its proper position, the laborer brings the rods in front of both plates, and the operation is repeated. The other laborer takes meanwhile the first plate put down and brings it to the front as No. 4. The thermometer is read from time to time on the shady and sunny side of the rod, to obtain its temperature. After a reasonable practice the rate of measurement may be assumed as 20 feet for each interval of one and one-half minutes.

CO-EFFICIENT OF EXPANSION.

The steel rods of the U. S. Coast Survey are of normal length at the temperature of 61°.6 Fahr. By means of the co-efficient of expansion for one degree, as given in Lee's tables, the distance of 20 feet is reduced by applying the temperature of the time of comparison, and thereby the distance between both knife-blades is obtained. To this is added the readings of the scales of the rod, and the length of the rod for the observed temperature is found. The mean of the observations at low and high temperatures are taken, and from the difference of both lengths the factor of expansion is derived, as shown in the next table.

Date.	Comparisons at low temperature.						Comparisons at high temperature.					
	Thermometer reads 61°.6.	Knife-blades distant by reading, 20 feet.	Corrections for expansion of 20-foot steel rod.	Actual distance of knife-blades, 20 feet.	Sum of readings of wooden rod.	Wooden rod equal to 20 feet.	Thermometer reads 61°.6.	Knife-blades distant by reading, 20 feet.	Corrections for expansion of 20-foot steel rod.	Actual distance of knife-blades, 20 feet.	Sum of readings of wooden rod.	Wooden rod equal to 20 feet.
1876.	°	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	°	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
Sept. 23	−14.1	−1.4850	−0.0315	−1.5165	0.4950	−1.0215	+35.4	−1.5500	+0.0790	−1.4710	0.5110	−0.9600
24	− 4.5	−1.4850	−0.0101	−1.4951	0.4840	−1.0111	+26.4	−1.5430	+0.0585	−1.4845	0.5000	−0.9845
25	−10.2	−1.4960	−0.0157	−1.5117	0.4990	−1.0127	+38.4	−1.5540	+0.0861	−1.4679	0.4940	−0.9739
26	− 7.8	−1.5150	−0.0116	−1.5266	0.5050	−1.0216	+48.4	−1.5600	+0.0732	−1.4868	0.5180	−0.9688
27	−10.6	−1.5000	−0.0163	−1.5163	0.5070	−1.0093	+32.4	−1.5580	+0.0587	−1.4993	0.5220	−0.9773
28	− 2.1	−1.5150	−0.0047	−1.5197	0.5170	−1.0027	+11.4	−1.5400	+0.0239	−1.5161	0.5220	−0.9941
29	− 6.0	−1.5100	−0.0134	−1.5234	0.5270	−0.9964	+22.0	−1.5360	+0.0436	−1.4924	0.5130	−0.9794
30	− 4.5	−1.5130	−0.0101	−1.5231	0.5220	−1.0011	+47.0	−1.5641	+0.0731	−1.4910	0.5300	−0.9610
Oct. 1	− 5.3	−1.5260	−0.0119	−1.5379	0.5300	−1.0079	+11.6	−1.5410	+0.0174	−1.5236	0.5410	−0.9826
2	− 1.7	−1.5340	−0.0037	−1.5377	0.5410	−0.9967	+60.4	−1.5640	+0.0962	−1.4678	[illegible]	−0.9178
3	− 6.5	−1.5180	−0.0146	−1.5326	0.5350	−0.9976	+44.4	−1.5750	+0.0677	−1.5073	0.5420	−0.9653
4	− 6.5	−1.5350	−0.0146	−1.5496	0.5410	−1.0086	+52.4	−1.5730	+0.0860	−1.4870	0.5420	−0.9450
5	− 6.5	−1.5330	−0.0146	−1.5476	0.5390	−1.0086	+66.4	−1.5890	+0.0922	−1.4968	0.5510	−0.9458
6	−10.2	−1.5330	−0.0156	−1.5486	0.5410	−1.0076	+36.4	−1.5740	+0.0661	−1.5079	0.5660	−0.9419
7	− 3.8	−1.5440	−0.0085	−1.5525	0.5410	−1.0115	+15.4	−1.5730	+0.0361	−1.5369	0.5340	−1.0029
8	+ 0.4	−1.5380	+0.0009	−1.5371	0.5400	−1.0794	+17.6	−1.5740	+0.0395	−1.5345	0.5510	−0.9835
10	−12.0	−1.5380	−0.0268	−1.5648	0.5590	−1.0058	+38.4	−1.5700	+0.0860	−1.4841	0.5220	−0.9621
11	− 3.8	−1.5370	−0.0086	−1.5456	0.5590	−0.9866	......	......	......	......	......	......
11	− 1.8	−1.5370	−0.0040	−1.5410	0.5410	−1.0000	......	......	......	......	......	......

Mean length of rod at 54°.5 Fahr.=20 feet−1.0062 inch.
Mean length of rod at 99°.0 Fahr.=20 feet−0.96556 inch.

Expansion of rod for 44°.5 Fahr.=0.04064 inch.
Expansion of rod for 1°.0 Fahr.=0.00091 inch.

REDUCTION OF OBSERVATIONS.

The following corrections are applied to the number of rods multiplied by 20 feet:

(1) Difference of rod from 20 feet at mean temperature of all observations multiplied by the number of rods measured.

(2) Readings of both ends of wooden rod when lying on the plates.

(3) Correction for inclination.

The following table contains the corrections for (1):

Date.	First measurement.			Date.	Second measurement.		
	Mean temperature.	Number of rods measured.	Equivalent number of rods of 20 feet.		Mean temperature.	Number of rods measured.	Equivalent number of rods of 20 feet.
			Inches.				*Inches.*
Sept. 23	88	104	−101.3467	Oct. 5	93	144	146.6887
24	90	104	−102.1897	6	97	151	166.1710
25	60	54	− 52.6965	7	92.6	158	167.7516
26	88	109	−106.5279	8	83	150	151.9837
27	65	102	−101.0823	10	88	145	141.3302
28	81	104	−102.1961	11	86	129	120.3645
29	88	111	−108.2537	17	65	148	139.4297
30	84	105	−102.9889	18	67	150	141.7125
Oct. 1	83	98	− 95.2362				
2	94	108	−104.9734				
3	90	110	−108.3146				
4	85	72	− 70.4319				

First measurement, 1,181 rods—1,155.2556 inches. Second measurement, 1,179 rods—1,142.4080 inches.

DEDUCTION OF RESULTS OF LENGTHS OF BASE NEAR SUTRO, NEV.

	First measurement.	Second measurement.
Sum of corrections for (1)	− 96.2713	− 95.2007
Sum of corrections for (2)	−101.2006	− 62.2867
Sum of corrections for (3)	− 1.1624	− 1.1493
Sum of corrections	−198.6343	−155.3466
Number of rods multiplied by 20 feet	23620.0000	23580.0000
Length of base	23421.3107	23421.2566
Mean		23421.322
Reduction to the level of the sea		− 4.995
Resulting length (feet)		23416.327

GEODETIC AND TOPOGRAPHIC.

It becomes important to determine astronomically the longitudes and latitudes of a sufficient number of stations as points of departure for surveys, and as subsequent checks upon an extended triangulation. It having been determined upon to prosecute the survey over a given region, the most convenient astronomical station is selected, if one has been determined within or sufficiently near the area, or else observations to determine the co-ordinates of a well-selected point must be made. The location of the site for a base-line in the vicinity is selected, if practicable, upon a plain or in a valley surrounded by mountain ridges, so that its direction shall be nearly coincident with the longer axis of the curve passing through the triangulation points lying within its horizon. The extremities of the base are then permanently marked, and frequently stations along it. Base measurements have been made by the wooden rod, approximately 20 feet in length, heretofore described, careful comparisons being made before and after each day's measurement. Each base is measured at least twice, or forward and backward, and the mean of the results taken. The astronomical azimuth of the base is determined from either extremity, and from one of the extremities to the end of a developed base being the vertex of one of the surrounding triangles. The vertices of the surrounding triangles are so selected that the direction of the line of greatest distance between any two is such that this triangular side with each of the two others joining with the majority of the main triangulation stations shall make a number of well-shaped or as nearly isoceles triangles as possible. From observations made at the vertices of a sufficient number of triangles a proper connection is made between the initial astronomical point and each of the main triangulation stations surrounding it. The grade of the observations made at developed triangulation points is the same as that employed at the main stations.

MAIN TRIANGULATION STATIONS.

These are selected in advance, usually prominent mountain peaks, buttes, mesa edges, and from among natural objects easily identified, so that the triangles of which they become the vertices shall be as nearly equilateral as practicable. Main triangles usually quadrilaterally connected, having sides from 20 to 60 and 70 miles in length, cover the entire area. Sides of triangles of greater length than 40 miles are to be avoided when possible. From six to ten and twelve pointings are made from each station to each adjacent station of the same order within the horizon.

The instrument used* is a transit theodolite of 10 or 8 inch limb, graduated to read by vernier to 5 or 10 seconds in arc, and with magnifying power sufficiently strong to recognize objects at a distance of 75 miles in the rare clear atmosphere of the western mountains. Both vernier and repeated angles are read at each station. A profile of the entire horizon, usually consisting of mountain ridges, is then made, serving to identify distant stations and aiding also the topographer. Angles of elevation and depression are read to the most prominent mountain peaks. The azimuth of one side of each triangle is required. Incidentally the variation of the needle is determined. The set of meteorological observations is taken at extremities of measured and developed bases, and also main and secondary triangulation stations. The point is marked by a compact conical-shaped mound of stones, in which a staff is firmly imbedded. A record of the occupation, on parchment paper, incased in a metallic box, is left buried in the cairn.

The computed positions of the main stations give the co-ordinates of a large number of initial points not alone of value in current mapping enterprises, but which will prove of permanent usefulness in the future as more details are added to existing maps, and might now be availed of with advantage to the land surveys in checking their main and minor lines.

SECONDARY TRIANGULATION STATIONS.

These stations are selected among minor peaks and natural objects, usually at lower altitudes than the main stations. The belts of triangles connecting these stations do not necessarily make a network covering the entire area, but embrace the mountain portions lying between the valleys and plains. The observations are frequently made with the same instruments and in like manner to those at the main stations, with fewer multiplications. A triangulation instrument of lesser graduation and focal power may be used, and the observations repeated from three to five times. The horizon sketch, barometric observations, etc., are the same as at main stations. The sides of the secondary triangles vary in length from 2 to 20 miles.

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*The triangulation instrument used at the main triangulation stations is the result of the experience of the survey, combining portability and strength with the requisite accuracy. It may also be available for astronomical time and azimuth observations.

THREE-POINT STATIONS.

These may be minor peaks or topographic objects, but are usually taken along measured lines. Each station must be in clear view of three others determined in position as main or secondary triangulation stations. The readings are made by a transit theodolite, graduated to read by vernier to one minute. Aneroid readings are always taken, but not necessarily the full set of meteorological observations, variation, etc., as is required at main and secondary stations The number of this class of stations is great as compared with main and secondary stations. The longitude and latitude of the most important are computed, and others are reduced graphically.

CROSS-SIGHT STATIONS.

These points lie outside of the area being occupied, and are such as may be available for main triangulation stations for occupation in subsequent seasons. From the main station at which pointings are taken these stations are treated the same as a distant main triangulation station, and they come into the system of triangulation as the same is extended to include them.

The following is an example of the form employed for field triangulation observations:

Date, August 12, 1877. Station, Mount Pisgah. Observers, Lieut. S. E. Tillman and Topographer G. Thompson. Instrument, Stackpole No. 1459.

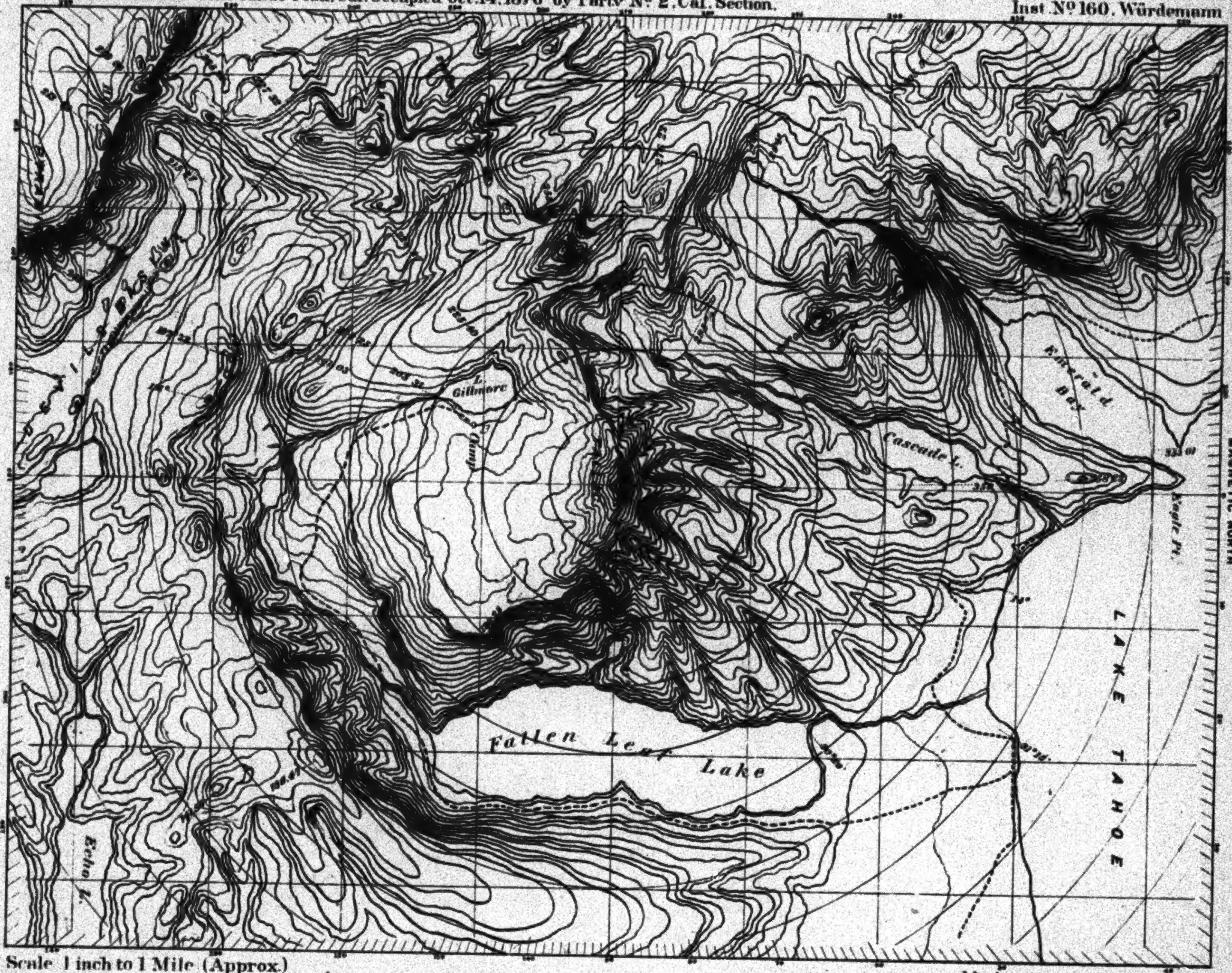
Objects.	Readings, 1° set.		Mean of A. & B.	Differential angles.	Readings, 4° set.		Mean of A. & B.	Differential angles.
	Vernier A.	B.			Vernier A.	B.		
	° ′ ″	′ ″	′ ″	° ′ ″	° ′ ″	′ ″	′ ″	° ′ ″
Meade Peak	0 0 2	0 0	0 0		300 0 0	0 0	0 0	
Castle Rock	15 20 55	20 55	20 55	15 20 55	315 20 10	20 10	20 10	15 20 10
Sherman Peak	20 5 5	4 45	04 55	4 25 00	320 4 10	4 10	04 10	4 25 00
Oxford Peak	39 51 30	51 30	51 30	19 46 35	339 51 35	51 25	51 30	19 47 20
Sedgwick Peak	42 36 25	35 55	36 10	2 44 40	342 36 10	36 10	36 10	2 44 40
Elkhorn (?)	49 25 30	25 20	25 25	6 49 15	349 25 40	25 40	25 40	6 49 30
S. Putnam Peak	78 4 10	4 0	04 05	28 38 40	18 3 15	2 55	03 05	28 37 25
Mount Putnam	82 5 25	4 55	05 10	4 1 5	22 5 35	5 25	05 30	4 2 25
North end Mount Putnam	197 12 40	12 30	12 35	115 7 25	137 12 50	12 30	12 40	115 7 10
Tetons	214 4 30	4 20	04 25	16 51 50	154 4 35	4 25	04 30	16 51 50
Mount Baird	214 52 25	51 55	52 10	0 47 45	....	....	....	
Peak	275 8 0	7 50	07 55	60 15 45	215 7 45	7 15	07 30	61 3 00
Point	290 40 45	40 45	40 45	15 32 50	230 40 10	39 50	40 0	15 32 30
Wyoming Peak	318 13 15	13 5	13 10	27 32 25	....	....	....	
Meade Peak	360 0 0	0 0	0 0	41 46 50	300 0 5	59 55	0 0	69 20 00

TOPOGRAPHIC MEANDER STATIONS.

These independent of the astronomic and trigonometric positions occur at short intervals along the measured lines that follow the roads, trails, streams, divides, natural routes of communication, and, in fact, over nearly all traveled routes. The angles of deflection of the line and its azimuth, from given points, are read by a transit theodolite specially made for the survey, of 3½-inch limb, and graduated to read to minutes in arc by the vernier, and of focal power necessary for distances not exceeding 12 miles. The observations at these stations are made by the topographer and recorded upon book blanks of special form; those at the three grades before mentioned by the observer, and are recorded upon special forms. The number of this grade of stations is determined by the sinuosities of the road, the complexity of the topography, and the scale required for the map.

Horizontal Sketch from Tallac Peak, Cal. Occupied Oct. 14. 1876 by Party No 2. Cal. Section.

Inst. No 160. Würdemann


MAGNETIC NORTH
Eagle Pt.
LAKE TAHOE
Emerald Bay
Cascade L.
Fallen Leaf Lake
Gillmore L.
Camp
Echo L.

Scale 1 inch to 1 Mile (Approx.)

Magnetic Azimuth, 0° 0' 0"

Mountain Stations. Form 1. (Horizontal Sketch.)

The assistant engaged upon topographic work takes the necessary angles and sketches at all the stations of the several grades, and records them in blank forms specially prepared for the uses of the survey, the principal of which are the "mountain station" and "topographical" (examples as engraved plates herewith, forms 1, 2, and 3) books. The observations at main and secondary triangulation stations include a profile sketch of the entire horizon, the marked points being governed by measured angles, a horizontal sketch in contour of the declivities from the summit to the levels of the adjacent valley or plain, particular attention being paid to the character and direction of drainage, sources of which are usually found at each station occupied. Horizontal sketches of the adjacent topography are made at each "three-point" and "meander" station, and sketches at points arbitrarily selected of all marked topographic reliefs. He also notes the changes in elevation given by the aneroid readings, and enters at each station all notes of practical importance, whether actually needed for the map or indicative of the surface of the country, and the limits of the grades of land that are required to be designated. Each horizontal sketch thus made overlaps each succeeding one, and each sheet of the topographic record-book thus serves as a rude plane table, the reduction from which, referred to the initial points of the several grades, make a connected plot completely delineating the entire area. Measurements along the roads, trails, water courses, etc., result from the number of revolutions, indicated by an odometer, of a single wheel attached by shafts and other rigging to an animal, usually a mule, ridden by the observer. The actual number of revolutions to the mile made by the wheel is found from practical tests on different classes of traversed routes, and also over the different profiles found of each class. Tables are then prepared, from which the distance for any given number of revolutions can be taken, the arguments being the character and profile of the route and the number of revolutions per mile resulting therefrom. The recorder enters also the aneroid readings at each station of the route, indicates the character of each camp, as to wood, water, grass, and other camping facilities. He notes also the general character of the country, its opportunities for travel, the nature of the landscape, the amounts of timber and grass, and information concerning springs, streams, etc. In plotting the measured meanders allowance is made for the sinuosities of the road and the differences in elevation. The former is reduced by estimation; the latter is governed by the aneroid profiles.

Where more detail and greater care in the delineation of this class of contours is required, in special and restricted areas, the portable plane table, specially constructed for mountain work, and the usual methods incident thereto, has been employed, an example of which is the special survey of the Washoe mining region.

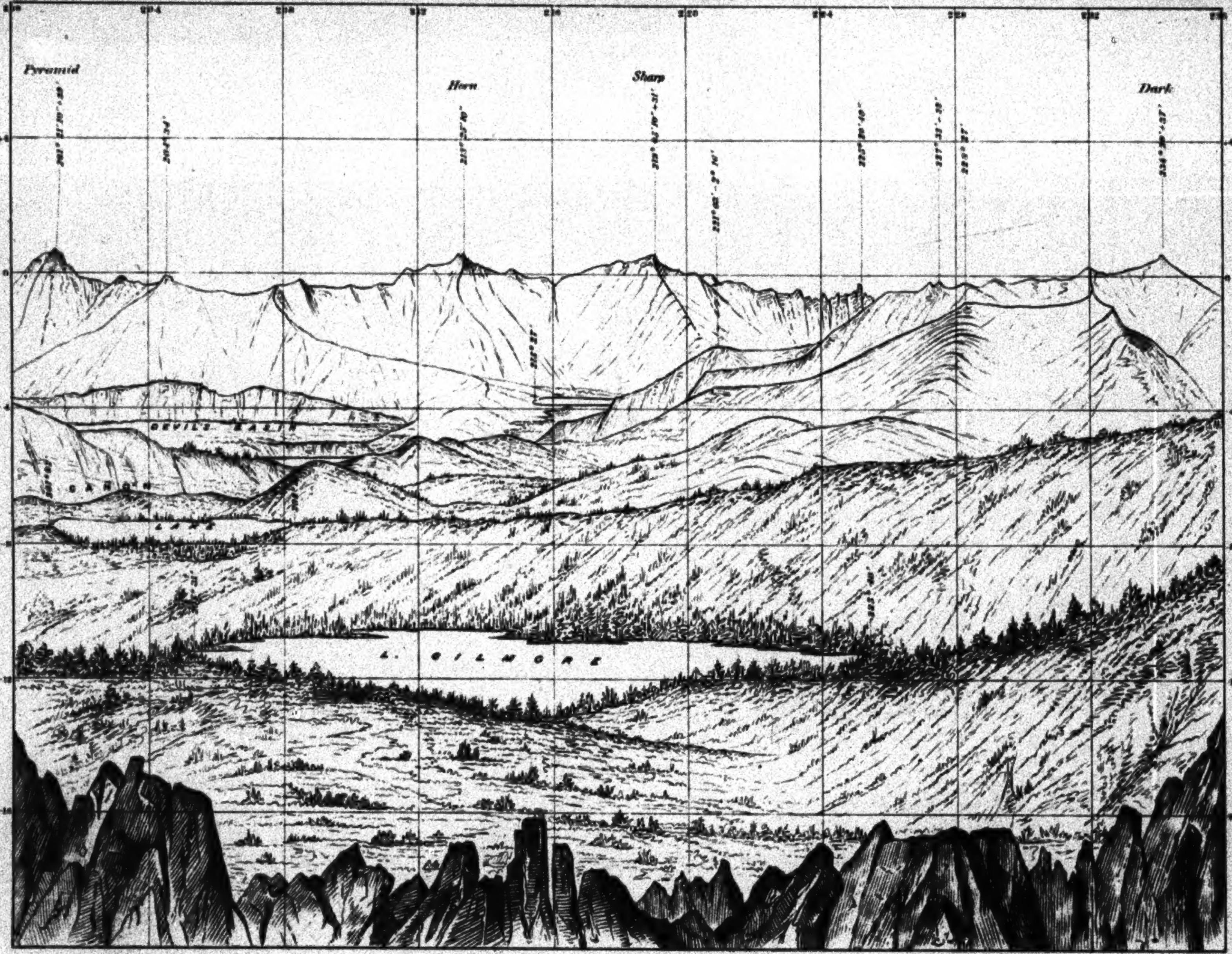
To a limited extent, stadia distances, between topographic stations, have also been made available.

In addition to the number of altitudes resulting from cistern and aneroid barometer observations, those deduced from vertical angles of elevation and depression taken by the topographer upon all marked points from each of the stations form no inconsiderable number. Variations of the needle are determined at each camp and at all stations of importance. The method employed is by observations upon Polaris at its elongation, the most rapid and accurate where an ordinary field-transit theodolite is employed, or by observing the magnetic azimuth of Polaris at any of its hour angles, the local time being given or known. The magnetic needle is not used in observing courses, except along unimportant meanders, and its use is to be discouraged even in these cases.

The degree and amount of evaporation are determined on lakes, ponds, and rivers of importance, and streams are gauged usually at their point of leaving the foot-hills for the valleys or plains. For the latter measurements the method given in Lee's tables has been adopted.

The instructions contemplate a connection, trigonometrically or by offsets, with stakes marking the surveys of the public lands where found. In the case of offsets the compensated steel tape or chain is used. The section of the survey bordering on the Pacific coast has been directed, where practicable, to join, by a triangulation connection, with monuments and stakes of the U. S. Coast Survey. The same holds good in all the sections with regard to monuments of international boundaries and those between political divisions.

Horizon Sketch from Tallac Peak, Cal. Occupied Oct. 14. 1876 by Party Nº 2. Cal. Section. Inst. Nº 160. Würdemann


200
204
208
212
216
220
224
228
232
236
+4
0
-4
-8
-12
-16
Pyramid
Horn
Sharp
Dark
DEVIL'S BASIN
LAKE
L. GILMORE

Scale: 1 inch to 4 Degrees. Magnetic Azimuth. 0° 0′ 0″.

Mountain Stations. Form 2. (Horizon Sketch.)

The recording of the notes upon which to base the delineation of the land traversed into agricultural, non-agricultural, timbered, grazing, mineral, etc., is mandatory. The data are entered in the topographic field-books, and the description is prepared by the chief of party and the topographer.

Magnetic observations for the determination of declination, dip, and intensity are taken, when practicable, at main astronomical stations and elsewhere, by means of a portable magnetometer and dip circle.

Herewith are graphic examples of "Mountain Stations" (Forms 1 and 2), and Topographic Meanders (Form 3), and field and explanatory notes (two pages).

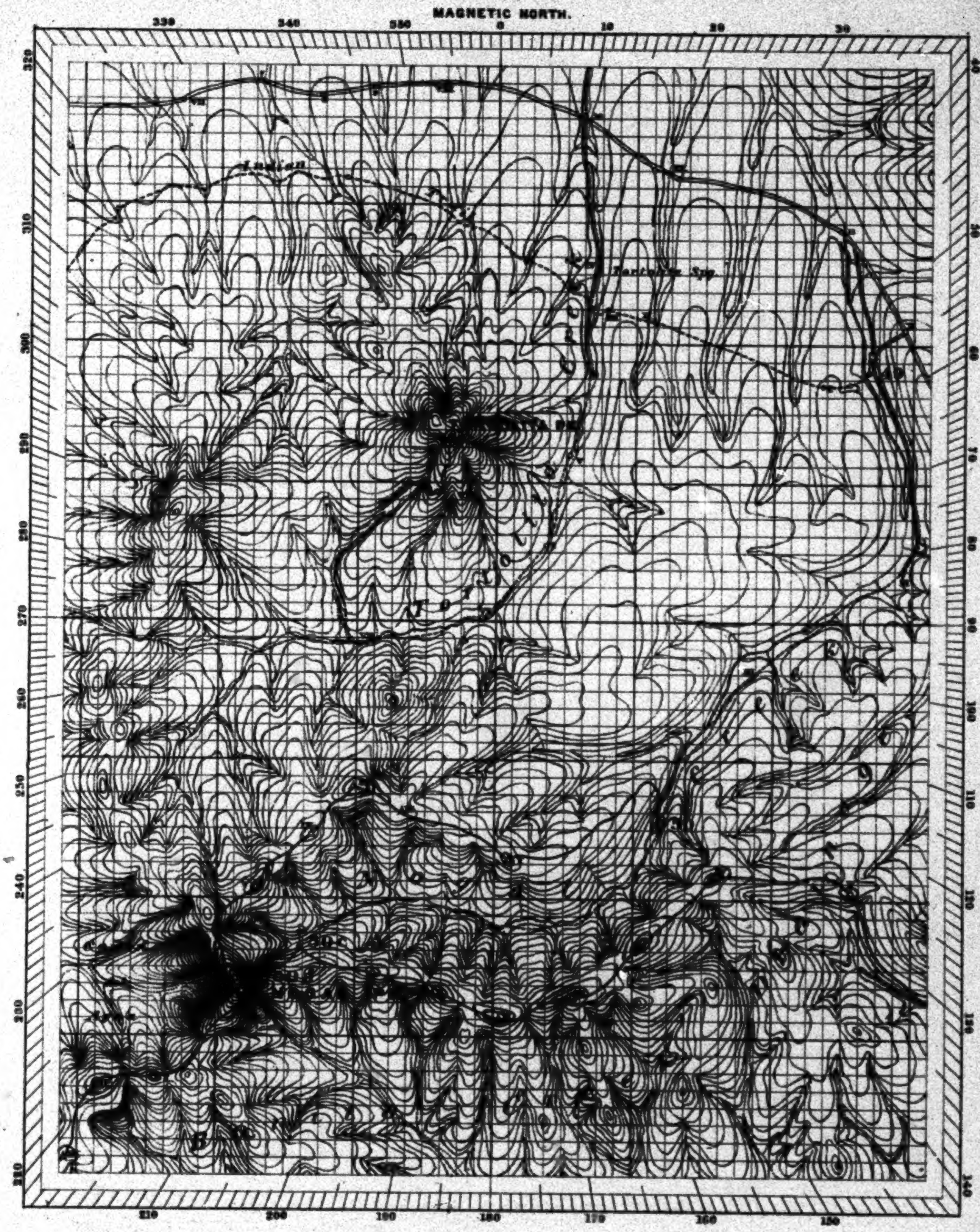
Camp No. 48 to No. 49, at Nogal Creek, N. Mex. Topographer, Frank O. Maxson. Date, August 8, 1877. Instrument used, 4892, Young & Sons. Party 2, Colorado Division. Magnetic variation Camp 48, 12° 33'. Lat., ——. Dep., ——. Miles surveyed, 21.32. Miles unsurveyed, ——. Total, 21.32.

Station.	Time.		Distance by—		Per cent. reduction.	Bearing.	Aneroid No. 4.			
	Arrive.	Leave.	Reading.	Miles.			Inches.	Temp.	Feet.	
VII	12.24	12.32	46.00	.65	1	73	24.100	....	5,785	187. 49 Camp Sta. Nogal, 221-28. Cone and range, 235-40. Jic., 236-45. Wooded pt. E. of So. Bl. range, 122-30. Camp E. ½ mile.
7	......	12.43	......	.45	1	96	......	....	......	
8	......	12.49	......	.40	1	76	......	....	......	
9	......	12.55	......	.61	1	88	......	....	......	
VIII	1.05	1.18	55.00	1.02	2	108	24.050	....	5,845	Jic., 256.
10	......	1.33	......	.82	2	122	......	....	......	
IX	1.46	2.00	62.85	1.07	2	168	23.940	....	5,960	
11	......	2.16	......	1.07	2	148	......	....	......	
X	2.32	2.40	72.00	.32	3	218	22.880	....	6,220	Nogal, 225. Jic., 237½.
49	2.48	7.12	73.35	.18	7	227	......	....	......	Aug. 9, 1877. 189 II. M. M., 109-22. Car, 88-05. H. p. c., 112-18. Cone, 123-26. Tortolita, 249-51.
1	......	7.16	......	.24	5	275	......	....	......	
I	7.20	7.22	......	1.38	3	290	23.750	75	6,050	189 VIII. Post marked I. R., XVI., 298. M. M., 225-00. So. Bl., 54-56. Nogal, 77-88. Bare Hill, 10-28. Bare cone S. of mountains, 365-22.
II	7.45	7.50	......	.30	3	303	23.660	65	6,205	
III	8.05	8.08	......	.24	4	354	23.825	76	5,975	
IV	8.13	8.23	......	1.32	5	190	23.825	77	5,975	Tortolita Spg. 189 IX. Tortolita Peak. M. M., 268-38. So. Bl., 127-58. Nogal, 149-57. N. So. Bl., 143-53. Sal., 184-06. Mesa end, 186-06. Hat pk., 196-47 (–49'). Round Mt., 198-30 (–1° 20'). Sh. p. N. end So. Bl range, 150-00 (–51'). Cow-ranch, 328-28. Car, 265-40 (+49'). Wooded cone, 230-40 (–4½'). Bare cone, 244-47 (–40'). Cap., 18-48 (+27'). Cone H. p. c. So. Bl., 101-00 (+58'). Ranch passed in coming up 65 mag. Lake, 87½-88 mag. Sta. X. of yes., 76½ mag. Ranch 77¾ mag.
V	8.43	8.48	......	.73	8	185	23.650	82	6,150	At 8.57 ranch left.
3	......	9.00	......	.73	8	220	......	....	......	
VI	9.12	9.18	......	1.02	2	208	23.400	88	6,425	
VII	9.36	10.21	......	1.39	3	22	23.280	80	6,565	

Station.	Time.		Distance by—		Per cent. reduction.	Bearing.	Aneroid No. 4.			
	Arrive.	Leave.	Reading.	Miles.			Inches.	Temp.	Feet.	
VIII	11.07	11.17	....	.20	10	15	22.320	82	7,640	191 X. West Tortolita Pk. M. M., 62-10. So. Bl., 245-53. Nog., 206-28. Sal., 142-11. 159, 196-38. Car., 65-07. Round Mt., 316-02. Need malpais, 27-46. Cow-ranch, 59-32.
IX	11.35	1.00	....	.18	7	......	21.960	80	8,160	
X	1.13	1.55	....	10.60	......	......	21.040	79	8,120	No survey to Camp 49.
49	6.00	6.50	72.35	.37	1	155	....	......	....	Aug. 10, 1877.
I	7.00	7.05	75.30	.78	1	175	22.020	....	8,050	
1	....	7.15	....	.25	3	205	....	......	....	
II	7.29	7.34	80.10	1.42	3	233	22.060	....	8,100	
III	7.48	7.50	88.20	1.83	5	210	22.300	....	8,225	
IV	8.29	....	94.60	.47	8	30	22.050	...	8,720	
50	8.45	8.50	98.00	1.40	......	......	....	......	....	
I	10.25	10.30	....	.80	......	......	22.050	74	7,780	192 I. N. So. Bl., 66-33. Nog., 107-08. Tortolita, 216-10. Cone located, 186-10.
II	10.55	11.00	....	.80	......	......	21.740	74	8,125	193 II. M. M., 60-00. So. Bl., 245-30. N. So. Bl., 204-05. Nog., 200-20. Tortolita, 76-58.
III	11.20	....	....	.90	......	......	21.690	75	8,210	194 III. M. M., 258-03. So. Bl., 106-55. N. So. Bl., 125-05. Nog., 140-57. Tortolita, 300-22.

Camp No. 50 to No. 50a, at Nogal Creek, N. Mex. Topographer, Frank O. Maxson. Date, August 8, 1877. Instrument used, 4692, Young & Sons. Party 2, Colorado Division. Magnetic variation Camp 48, 12° 33′. Lat., ——. Dep., ——. Miles surveyed, 21.32. Miles unsurveyed, ——. Total, 21.32.

Station.	Time.		Distance by—		Per cent. reduction.	Bearing.	Aneroid No. 4.			
	Arrive.	Leave.	Reading.	Miles.			Inches.	Temp.	Feet.	
IV	11.40	....	....	.40	......	......	21.515	79	8,515	Aug. 10, 1877. 195 IV. M. M., 239-30. So. Bl., 53-21. Nog., 82-08. Tortolita, 300-21.
V	11.50	....	....	2.50	......	......	21.400	76	8,630	196 V. M. M., 257-05. So. Bl., 66-43. Nog., 86-30. Tortolita, 282-31.
Nogal Peak	12.40	....	....	....	......	......	....	......	....	Primary triangulation station No. 3 occupied Aug. 10 and 11, 1877. Camp 50a is on slope of station about 200 feet from the top, due east.
Nogal Peak	....	11.00	....	1.25	......	230	....	......	....	Aug. 11. Meander by ridge toward So. Bl.
I	....	12.00	....	.60	......	261	....	......	....	197 I. M. M., ——. So. Bl., 230-30. N. So. Bl., 347-50. Nogal, 216-55 (+8°—25′).
II	12.12	12.31	....	.85	......	207	....	......	....	198 II. M. M., 196-50. So. Bl., 297-31. N. So. Bl., 312-42. Nogal, 196-27 (+8°—30′). East Cone, 250-35.
III	12.48	1.10	....	.65	......	210	....	......	....	199 III. M. M., 321-10. So. Bl., 118-14. N. So. Bl., 131-45. Nogal, 9-40 (+3°—10′). East Cone, 60-38.
Camp 50a	....	7.05	....	1.15	......	125	....	......	....	In cañon of Nogal Ck., about 1 m. N. E. of Nogal Pk. Aug. 12, 1877.
I	7.15	7.35	....	1.06	......	111	....	......	....	205 I. M. M., 44-53. So. Bl., 218-49. Nog., 205-56 (+11°—05′). N. So. Bl., 241-53. Cone E., 172-30.
II	8.02	8.13	....	.84	......	70	....	......	....	206 II. M. M., 250-15. So. Bl., 71-52. Nog., 167-45 (+5°—15′). N. So. Bl., 98-24. Tortolita, 347-22.
III	8.27	8.40	....	1.23	......	100	....	......	....	207 III. M. M., 210-28. So. Bl., 44-30. Nog. 130-30 (+4°—15′). N. So. Bl., 71-38. Tortolita, 300-16.
IV	9.20	9.23	....	1.15	......	146	....	......	....	208 IV. M. M., 41-37. So. Bl., 202-35. Nog., 280-30 (+3°—47′). N. So. Bl., 236-53. Tortolita, 13-28.
V	10.00	10.20	....	.60	......	180	....	......	....	209 V. M. M., ——. So. Bl., 260-50. Nog., 88-46 (+4°—03′). N. So. Bl., ——. Tortolita, 116-04.
VI	11.14	11.34	....	1.94	......	100	....	......	....	210 VI. M. M., 104-15. So. Bl., ——. Nog., ——. N. So. Bl., ——. Tortolita, ——. Cone E., 206-32. Carr, 68. Cone E. of Cone E., 266-00. Pajarito, 163-45. Bare Cone E., 114-21.


MAGNETIC NORTH.
330
340
350
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
Indian
Tortoise Spg

Main-route and Side Meanders, and Topographical Stations.

Form 3.

(Scale: 1 inch to 1 mile)

BAROMETRIC ALTITUDES.

Differences in altitude resulting from barometric observations are obtained for each of the stations of the several grades of observations. These are divided into *cistern* and *aneroid* barometer observations. A set of the cistern barometer observations consists of the reading of the mercurial column by a vernier scale, and of the attached thermometer for temperature of the column, and of the wet and dry bulb thermometers. The anemometer, when at hand, indicates the force of the wind, its direction, while the character and extent of clouds are also estimated. The maximum and minimum thermometers are each recorded once during every twenty-four hours. At main astronomic stations the rain-gauge is also employed. Aneroid barometer readings are in all cases referred to those of the cistern barometer, and frequently during each twenty-four hours the comparative index error is determined. Aneroid observations consist of reading by the index arm the inches and decimals of an inch, and upon the altitude scale the number of feet, as also the attached thermometer. The general meteorological conditions are noted and the hygrometers are frequently read. The methods of observation, of reduction, care, repair, and filling of instruments are described in the manual of instructions. (There are three editions. See list of reports and maps, 1881.)

The temperature of mineral and thermal springs of the area surveyed is noted, and specimens therefrom taken for examination and analysis.

The difference of readings of the wet and dry bulbs in the atmosphere adjacent to and over surfaces of water, as lakes, ponds, hot springs, rivers, etc., is in many instances noted. For the observations in the branches of mineralogy and mines, geology, paleontology, zoology, botany, and archæology, usually made by experts and specialists, requiring but few instruments,[*] the eye unaided so frequently noting phenomena, no formulated methods as guides have so far been devised. Different observers may reach the same results by slightly different methods. The collection of data is dependent upon the objects sought, whether scientific or practical.

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[*] The principal instruments of the geologist are the geological pick and hammer, the clinometer compass, pocket level, and aneroid barometer, the lines of demarkation of the superposed formations, where well defined, being impossible of exact measurement, even if that were requisite, the true thickness of exposed strata and beds being, however, more important.

The results are the determination of the structural geology of the region through chemic, petrographic, and paleontologic data, with characteristic profiles, the collection of fossils, vertebrates, and invertebrates from discovered beds. In mineralogy and mines* the examinations take a wider range, involving engineering plans and methods of execution, as in the mining and milling of ores, etc. Specimens are, when practicable, collected illustrating the lithological characteristics of all grades of rock, deposits of ores, from saline, alkaline, borax, and other beds.

In zoology collections of mammals, birds, fishes, insects, etc., are made, and when a sufficient amount of any one class is secured, are placed in the hands of a specialist for examination and report. The same rule applies in botany.† A study is made of the present and extinct Indian tribes as to their habits, language, customs, burial places, mounds, etc. Photographs of landscape and stereoscopic size are made when practicable, illustrative of peculiar landscape features, of particular geological formations, of ruins, and of several Indian tribes.

Exemplifications of the field barometric are herewith: (*a*) Cistern and aneroid barometer readings (Form I); (*b*) aneroid readings (Form III); (*c*) aneroid and odometer readings (Form IV):

(*a*). [FORM I.]—CISTERN AND ANEROID READINGS.

Party: No. 1, Utah section. Louis Seckels, observer.

CAMP NO. 28, TOLL-GATE (SUMMIT RANCH), PLUMAS COUNTY, CAL.

Date.	Standard Cist. bar., No. 1735.						Cist. bar. No. 1767.		Aneroid.				Thermometers.				Clouds.	Wind.	
	Hour.	Attached therm.	Reading.	Error = +.006.	Reduction to 32° F.	Barom. at 32°.	Attached therm.	Reading.	Attached therm.	No. 2 reading.	Attached therm.	No. 6 reading.	No. 3.		No. 4.			Direction.	Force.
													Max.	Min.	Dry.	Wet.			
1878																			
Sept. 20	2.00 p.m.	60.7	24.604	......	......	......	...	......	....	......	71	24.22	....	....	65.0	46.2	0	W.	0
Sept. 20	9.00 p.m.	33.2	24.629	......	......	......	33.5	24.612	35	24.46	25	24.23	70	...	33.5	31.4	0	SW.	2
Sept. 21	6.00 a.m.	27.6	24.614	......	......	......	27.8	24.613	30	24.47	30	24.22	....	30	28.8	27.4	0	W.	2
Sept. 21	7.00 a.m.	34.3	24.635	−.006	−.012	24.617	34.6	24.606	....	......	36	24.27	....	....	34.2	31.6	0	SW.	2

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*See list of mining questions, preliminary report, 1871, p. 32.

† Special survey forms regulate the field record in "natural history" and "botany." Special forms (not subject to issue) regulate the organization and equipment of field parties.

(a). [FORM I.]—CISTERN AND ANEROID READINGS—Continued.

FORKS OF THE ROAD, NEAR BRIDGE OVER BUTT CREEK, (ANEROID STATION 11).

Date.	Standard Cist. bar. No. 1735.						Cist. bar. No. 1767.		Aneroid.				Thermometer				Clouds.	Wind.	
	Hour.	Attached therm.	Reading.	Error ± .000.	Reduction to 32° F.	Barom. at 32°.	Attached therm.	Reading.	Attached therm.	No. 2 reading.	Attached therm.	No. 6 reading.	No. 5.		No. 4.			Direction.	Force.
													Max.	Min.	Dry.	Wet.			
1873. Sept. 21	12.15 p.m.	70.6	25.522	......	...	......	......	......	..	......	72	25.12	......	...	60.8	52.2	0	SE.	4
*BUTT MOUNTAIN, CIS. BAROM., 20 FEET BELOW SUMMIT.																			
Sept. 21	7.00 a.m.	....	....	......	.....	....	37.5	22.580	....	.....	....	......	....	...	33.5	29.5	....	....	...
Sept. 21	8.00 a.m.	....	....	......	......	....	40.0	22.600	....	.....	....	......	....	...	38.5	31.0	....	....	...
Sept. 21	9.00 a.m.	....	....	......	......	....	45.0	22.618	....	.....	....	......	....	..	42.5	31.5	....	....	...
Sept. 21	10.00 a.m.	....	....	......	......	....	49.5	22.634	..	.....	..	......	....	...	47.0	34.0	....	....	...

*Lieutenant Tillman, observer. Psychometer No. 7; No. 4 and Cist. barom. No. 1735 at Camp 22.

(b). [FORM III.]—ANEROID READINGS.

Party, main: Lieutenant Wheeler, observer. From Camp 8 to Camp 9. Date: August 24, 1874.

No. of observation.	Hour.	Aneroid.		Cistern No. 1735, Reading 32° F.	Error of aneroid.	Temperature.	Weather.	Aneroid, in feet.	Zero of feet scale set at inches.	Remarks.
		Number.	Reading.							
Camp.	6.00 a.m.	1719	22.35	22.715	–.365	48.4	Cumulus.......	7,610	29.65	Conejos, Colo.
1	8.15 a.m.	1719	22.35	....	–.370	50.5	....do	[illegible]	29.65	Ford of Conejos Creek, Guadaloupe, Colo.
2	10.00 a.m.	1719	21.695	....	–.370	74.5	....do	[illegible]	29.65	First ascent of mesa.
3	12.20 p.m.	1719	21.010	....	–.370	[illegible]	Cum. and wind	[illegible]	29.65	Saddle, near Prospect Peak, Colo.
4	1.00 p.m.	1719	20.84	....	–.370	70.2	Nim. and wind..	9,425	29.65	Prospect Peak, Colo.
5	2.00 p.m.	1719	20.81	....	–.370	[illegible]	....do	9,500	19.65	Do.
6	2.20 p.m.	1719	[illegible]	....	–.370	[illegible]	Rain	9,400	29.65	Do.
7	3.00 p.m.	1719	[illegible]	....	–.370	62.3	....do	9,400	29.65	Do.
Camp.	6.00 p.m.	1719	21.95	22.316	–.365	54.3	....do	8,000	29.65	On Conejos Creek, Colo.

NOTE.—Give locality of camp or station, with State or Territory in which situated. Take readings at *divides, crossings of streams, towns, ranches, settlements, mountain summits, etc.*, and, in general, all points which can be located without the aid of the topographer.

(e). FORM IV.—ANEROID AND ODOMETER READINGS.

Party: No. 1. Section, Utah. L. Seckels, recorder. From Camp No. 28, at Toll Gate (Summit Rock), to Camp No. 29, at Deer Creek Meadows, Cal. Date: September 21, 187-.

Station.	Hour.	Aneroid No. — reading.	Temperature.	Cist. bar. No. 1736.		Error of aneroid.	Odometer.			Aneroid in feet.	Zero set at inches.	Remarks.
				Reading.	Att'd T.		Reading.	Per mile.	Miles.			
No. 28	7.00 a. m.	24.97	° 50	24.630	° 54.3							
0	7.20	24.28				—0.25	000	426	0.000	5,150	29.65	Toll gate.
1	8.00	24.37	48				304	426	0.821	5,050	29.65	
2	8.45	24.28					763	426	1.081	5,000	29.65	
3	9.20	24.60					1245	426	1.861	4,825	29.65	
4	9.30	24.67					1590	426	0.800	4,775	29.65	
5	10.00	24.80	65				1858	426	0.656	4,625	29.65	
6	10.20	24.78					2061	426	0.528	4,600	29.65	Creek.
7	10.40	24.90					2299	426	0.563	4,625	29.65	Creek.
8	11.00	24.85					2578	426	0.654	4,575	29.65	
9	11.30	25.00					3014	426	1.024	4,450	29.65	
10	11.50	25.10					3296	426	0.660	4,350	29.65	
11	12.15 p. m.	25.13	73	25.323	70.6	—0.29	3452	426	0.362	4,300	29.65	Forks of road to Soldiers' Meadows.
12	12.55	25.00					3679	426	0.531	4,400	29.65	
13	1.10	25.10					3830	426	0.354	4,350	29.65	Butt Creek.
14	2.06	25.00	74				4495	426	1.561	4,450	29.65	
15	2.45	24.95					5221	426	1.704	4,475	29.65	
16	3.30	24.90					5752	426	1.262	4,500	29.65	
17	4.10	24.83	73				6435	426	1.646	4,575	29.65	Lost Creek.
18	4.35	24.90					6770	426	0.780	4,500	29.65	
19	5.30	25.05					7584	426	1.911	4,375	29.65	
20	5.45	25.10					7813	426	0.538	4,350	29.65	Camp No. 29.
No. 29	6.00 p. m.	25.12	61	25.362	62.0	—0.25			18.843			For comparison.

NOTE.—Compare aneroid with cistern immediately before leaving and after entering camp. The readings of the *aneroid* at these times are *essential*, and *must be taken to close the profile.*

The field instruments employed are as follows:

ASTRONOMIC, GEODETIC, TOPOGRAPHIC, AND BAROMETRIC INSTRUMENTS.

Astronomical transits.
Meridian transits (Coast Survey pattern).
Zenith telescopes.
Sextants and artificial horizons.
Astronomical clocks at observatories.
Mean solar and sidereal box-chronometers.

	Size of limb.
Transit theodolites	10 inch
Transit theodolites	8 inch
Transit theodolites	7 inch
Transit theodolites	6 inch
Topographers transit theodolites	3½ inch
Gradienter	3½ inch

Levels and staffs.
Alt-azimuths.

Pocket sextants.
Prismatic and pocket compasses.
Magnetometers.
Dip circles.
Five-foot steel standard rods (U. S. C. S. pattern).
Twenty-foot wooden rods, with scales and stands (Survey pattern).
Compensated steel tapes, 50 feet.
Steel and linen tapes, 50 feet.
Steel chains, 50 feet.
Odometers, with vehicles (Survey pattern).
Pedometers.
Cistern-barometers, double vernier, with mountain attachment.
Mean solar and sidereal pocket-chronometers.

ASTRONOMIC, GEODETIC, TOPOGRAPHIC, AND BAROMETRIC INSTRUMENTS—cont'd.

Mean-time watches.
Chronographs (cylinder and fillet patterns).
Personal-equation apparatus (Survey pattern).
Connecting switch-boards (Harkness pattern).
Break-circuit keys and battery.
Readings in arc by vernier to —
5 seconds.
10 seconds (Survey pattern).
30 seconds.
60 seconds.
60 seconds (Survey pattern).
60 seconds.
Mountain cistern barometers (special pattern).
Aneroid barometers, reading to 20,000 feet (Survey pattern).
Hygrometers (Survey pattern).
Pocket thermometers.
High temperature thermometers.
Maximum and minimum thermometers (Survey pattern).
Anemometers.
Aerometers.
Rain ganges.
One set field drawing instruments, with protractors, scale, rules, and triangles.

OFFICE.

ASTRONOMIC AND GEODETIC.

The office reductions necessary in the construction of the map and accompanying report are, computation of the latitudes, longitudes, and altitudes of points of the several orders of value, determined astronomically, geodetically, hypsometrically; the projection and construction of the triangulation and the preliminary plotting sheets and of the resulting topographic maps, upon which the land classification and geological sheets are based; in the computations of latitudes and departures, and for variations of the needle, and in the reduction of the meanders and other topographic data; the preparations of tables of distances, of longitudes, latitudes, altitudes, variations, etc; and in the reduction of magnetic and other observations. The reduction of the astronomical observations of two of the three grades employed has been adverted to, and those necessary for latitude results are made upon blank forms upon which are entered the arguments required in computations for errors of local times, from single or double altitudes of the sun or stars, from circum-meridian observations, and those upon Polaris off the meridian for latitude. The triangles are grouped in the best conditioned figures, and the necessary computations for the adjustments, distances, azimuths, latitudes, and longitudes are made as indicated in the examples herewith upon geodetic computations. Computations are also made of the main and secondary triangulation, cross-sight, and three-point stations.

The following are examples of the forms of astronomic computations (time by transit, and latitude by zenith telescope): (a) computations for time; (b) publication (time); (c) final longitude results; (d) transcript of latitude observations; (e) computations for latitude; (time and latitude by sextant and chronometer); (f) time by single altitude; (g) time by equal altitudes (h) latitude by circummeridian altitudes; (i) latitude by Polaris.

(a)—COMPUTATION OF OBSERVATIONS FOR TIME.

Colorado Springs, Colo., August 2, 1873. Before exchange of signals.

$\Delta T'_0 = -10^m\ 15^s.70.$

Clamp.	Name of star.	Δ_0 T.		aA.	a′A.	Δ_0 T′.		δT′.	A.	C.	A².	C².
		m.	s.	s.	s.	m.	s.	s.	s.	s.	s.	s.
E......	ε Coronæ.........	−10	15.36	+0.23	+0.02	−10	15.59	−0.11	+0.23	+1.12	0.05	1.25
E......	β′ Scorpii.........	10	14.66	+0.92	+0.07	10	15.58	−0.12	+0.92	+1.08	0.85	1.17
E......	δ Ophiuchi.........	10	14.84	+0.67	+0.05	10	15.51	−0.19	+0.67	+1.00	0.45	1.00
E......	ν Herculis.........	10	16.02	−0.20	−0.02	10	15.82	+0.12	−0.20	+1.46	0.04	2.13
E......	η Draconis.........	10	16.39	−0.83	−0.06	10	15.56	−0.14	−0.83	+2.12	0.69	4.49
E......	A Draconis.........	10	17.15	−1.41	−0.11	10	15.74	+0.04	−1.41	+2.80	1.99	7.84
W......	η Herculis.........	10	15.76	−0.01	0.00	10	15.75	+0.05	−0.01	−1.29	0.00	1.66
W......	κ Ophiuchi.........	10	15.21	+0.50	+0.04	10	15.71	+0.01	+0.50	−1.01	0.25	1.02
W......	ε Ursæ Minoris...	10	21.71	−5.09	−0.38	10	16.62	+0.92	−5.09	−7.41	25.91	54.91
W......	ω′ Herculis.........	10	15.48	+0.42	+0.03	10	15.90	+0.20	+0.42	−1.04	0.18	1.08
W......	44 Ophiuchi.........	−10	14.87	+0.98	+0.07	−10	15.85	+0.15	+0.98	−1.09	0.96	1.19
								+0.93	−3.82	−2.26	+31.37	+77.74

Clamp.	Name of star.	AC.	AδT′.	CδT′.	a°A.	cC.	S.	ΔT.		v.	v².
		s.	s.	s.	s.	s.	s.	m.	s.		
E......	ε Coronæ.........	+0.26	−0.03	−0.12	+0.25	+0.08	+0.33	−10	15.69	−0.05	0.0025
E......	β′ Scorpii.........	+0.99	−0.10	−0.13	+0.99	+0.07	+1.06	10	15.72	−0.02	0.0004
E......	δ Ophiuchi.........	+0.67	−0.12	−0.19	+0.72	+0.07	+0.79	10	15.63	−0.11	0.0121
E......	ν Herculis.........	−0.29	−0.02	+0.17	−0.22	+0.10	−0.12	10	15.90	+0.16	0.0256
E......	η Draconis.........	−1.76	+0.12	−0.30	−0.89	+0.14	−0.75	10	15.64	−0.10	0.0100
E......	A Draconis.........	−3.95	−0.06	+0.11	−1.52	+0.19	−1.33	10	15.82	+0.08	0.0064
W......	η Herculis.........	+0.01	0.00	−0.06	−0.01	−0.09	−0.09	10	15.67	−0.07	0.0049
W......	κ Ophiuchi.........	−0.50	+0.01	−0.01	+0.51	−0.07	+0.47	10	15.68	−0.06	0.0036
W......	ε Ursæ Minoris...	+37.72	−4.68	−6.82	−5.47	−0.50	−5.97	10	15.74	0.00	0.0000
W......	ω′ Herculis.........	−0.44	+0.08	−0.21	+0.45	−0.07	+0.38	10	15.86	+0.12	0.0144
W......	44 Ophiuchi.........	−1.07	+0.15	−0.16	+1.05	−0.07	+0.98	−10	15.85	+0.11	0.0121
		+31.64	−4.66	−7.73			Mean (11)	−10	15.745	±0.010	0.0920

NORMAL EQUATIONS.

$$\begin{array}{rl}
 & \text{s.} \\
0 = & +0.93 + 11.005\delta T' - 3.82a' - 2.26c \\
0 = & -4.66 - 3.823\delta T' - 31.37a' + 31.64c \\
0 = & -7.72 - 2.26\delta T' + 31.64a' + 77.74c \\
 & 0.58240 \quad 0.35411 \quad 1.50024 \quad (1.89064)
\end{array}
\qquad
\begin{array}{r}
\text{s.} \\
\delta T' = -0.045 \\
a' = +0.075 \\
c = +0.067 \\
a = +1.00 \\
a + a' = a^{0} = +1.075
\end{array}$$

$$\begin{array}{rrr}
-4.660 & -3.820 & +31.370 \\
+3.142 & +0.920 & -12.878 \\
\hline
-1.518 & -2.900 & +18.492 \\
0.18127 & 0.46240 & (1.26698) \\
+0.930 & +11.000 & -3.820 \\
-0.224 & -0.066 & +0.920 \\
\hline
+0.706 & +10.934 & -2.900 \\
-0.238 & -0.455 & \\
\cline{1-2}
+0.468 & +10.479 & \\
9.67025 & (1.02032) &
\end{array}
\qquad
\begin{array}{rrr}
+0.468 & -1.518 & -7.720 \\
9.67025 & +0.130 & +0.101 \\
\cline{2-2}
1.02032 & -1.388 & +2.375 \\
\cline{1-1}\cline{3-3}
8.64993 & 0.14239 & -5.244 \\
-0.045 & 1.26698 & 0.71966 \\
\cline{2-2}
 & 8.87541 & 1.89064 \\
\cline{3-3}
 & +0.075 & 8.82902 \\
 & & +0.067
\end{array}$$

(b).—FORM FOR PUBLICATION.

Colorado Springs, Colo. August 2, 1873. Before signals.

Name of star.	Clamp.	T.			bB.	aA.	cC.	T'.			AR.			ΔT.	
		h.	m.	s.	s.	s.	s.	h.	m.	s.	h.	m.	s.	m.	s.
ε Coronæ	E	16	02	36.71	+0.02	+0.25	+0.08	16	02	37.06	15	52	21.37	−10	15.69
β' Scorpii	E	16	08	19.57	+0.01	+0.99	+0.07	16	08	20.64	15	58	04.92	10	15.72
δ Ophiuchi	E	16	17	57.94	0.00	+0.72	+0.07	16	17	58.73	16	07	43.10	10	15.63
τ Herculis	E	16	26	12.94	+0.04	−0.22	+0.10	16	26	12.86	16	15	56.96	10	15.90
η Draconis	E	16	32	34.83	−0.01	−0.89	+0.14	16	32	34.07	16	22	18.43	10	15.64
A Draconis	E	16	38	33.66	+0.12	−1.52	+0.19	16	38	32.45	16	28	16.83	10	15.62
η Herculis	W	16	48	40.91	+0.09	−0.01	−0.06	16	48	40.93	16	38	25.26	10	15.67
κ Ophiuchi	W	17	01	59.35	+0.04	+0.54	−0.07	17	01	59.86	16	51	44.18	10	15.68
ε Ursæ Minoris	W	17	09	29.37	+0.27	−5.47	−0.50	17	09	23.67	16	59	07.93	10	15.74
α' Herculis	W	17	19	08.68	+0.05	+0.45	−0.07	17	19	09.11	17	08	53.25	10	15.86
44 Ophiuchi	W	17	28	53.97	+0.03	+1.05	−0.07	17	28	54.98	17	18	39.13	−10	15.85

Mean for 16h 35m local sidereal time, −10m 15s.745 ± 0s.020.

NORMAL EQUATIONS.

$$0 = +0.93 + 11.005t - 3.82a' - 2.26c$$
$$0 = -4.66 - 3.823t + 31.37a' + 31.64c$$
$$0 = -7.72 - 2.260t + 31.64a' + 77.74c$$

$a' = +0^{s}.075.$

$c = +0\ .067.$

Preliminary value of the azimuth, $a = +1^{s}.00.$

Azimuth of the instrument, $a + a' = +1^{s}.075.$

(c).—FINAL RESULTS FOR LONGITUDE.

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Double wave time.	Means.
1873.							
July 29.		h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	h. m. s.
Salt Lake City	Colorado Springs ...	18 09 00.11	−0 10 11.72	17 58 48.39			
	Salt Lake City	9 23 24.95	+8 07 05.46	17 30 30.41	0 28 17.98		
Colorado Springs ..	Colorado Springs ...	18 15 05.10	−0 10 11.72	18 04 53.38			
	Salt Lake City	9 29 30.17	+8 07 05.46	17 36 35.63	0 28 17.75	0.23	0 28 17.865
July 30.							
Salt Lake City	Colorado Springs ...	18 48 52.05	−0 10 12.48	18 38 39.57			
	Salt Lake City	10 03 16.16	+8 07 05.46	18 10 21.62	0 28 17.95		
Colorado Springs ..	Colorado Springs ...	19 00 15.66	−0 10 12.49	18 50 03.17			
	Salt Lake City	10 14 40.01	+8 07 05.46	18 21 45.47	0 28 17.70	0.25	0 28 17.825
August 2.							
Salt Lake City	Colorado Springs ...	18 39 07.63	−0 10 15.83	18 28 51.80			
	Salt Lake City	9 53 28.73	+8 07 05.11	18 00 33.84	0 28 17.96		
Colorado Springs ..	Colorado Springs ...	18 44 25.91	−0 10 15.83	18 34 10.08			
	Salt Lake City	9 58 47.24	+8 07 05.11	18 05 52.35	0 28 17.73	0.23	0 28 17.845
August 5.							
Colorado Springs ..	Colorado Springs ...	18 46 45.80	−0 10 18.30	18 36 27.50			
	Salt Lake City	10 01 05.27	+8 07 04.44	18 08 09.71	0 28 17.79		
Salt Lake City	Colorado Springs ...	18 51 25.60	−0 10 18.31	18 41 07.29			
	Salt Lake City	10 05 44.85	+8 07 04.44	18 12 49.29	0 28 18.00	0.21	0 28 17.895
August 6.							
Salt Lake City	Colorado Springs ...	18 17 05.32	−0 10 19.17	18 06 46.15			
	Salt Lake City	9 31 23.72	+8 07 04.49	17 38 28.21	0 28 17.94		
Colorado Springs ..	Colorado Springs ...	18 25 45.36	−0 10 19.18	18 15 26.18			
	Salt Lake City	9 40 03.97	+8 07 04.49	17 47 08.46	0 28 17.72	0.22	0 28 17.830

Final difference of longitude:

	h.	m.	s.	s.
Colorado Springs, Colo., east of Salt Lake City, Utah.	0	28	17.852	±0.009
Salt Lake City, Utah (Astronomical Monument), west of Washington, D.C.	2	19	22.74	
Washington, D.C. (Dome of Naval Observatory), west of Greenwich........	5	08	12.12	

Colorado Springs, Colo. (U. S. Engineer Astronomical Monument of Geographical Surveys), is hence—

	°	′	″		h.	m.	s.
West of Washington, D. C..	27	46	13.35	=	1	51	04.89
West of Greenwich	104	49	15.15	=	6	59	17.01

(*d*).—OBSERVATIONS FOR LATITUDE.

Station: Colorado Springs, Colo.

Date.	No. of star.	Micrometer-readings.		Level.		Remarks.
				N.	S.	
1873.		*t.*	*d.*	*d.*	*d.*	
Aug. 3	5567	13	2.6	16.9	25.4	Air little undulating
	5628	2	63.9	41.5	----	
	5747	7	23.7	19.8	22.3	
	5775	12	27.9	21.6	20.3	
	5790	5	73.0	21.3	20.7	
	5834	9	79.8	16.3	27.9	
	5978	18	32.0	22.3	19.5	
	5991	−0	78.7	13.0	29.0	
	6079	11	34.6	25.0	17.0	
	6110	7	5.9	9.3	32.0	
	6157	9	35.1	8.0	32.6	
	6228	2	62.5	24.0	17.7	
	6255	15	0.7	6.3	32.4	
	6257	13	31.0	20.0	22.0	
	6296	4	53.2	11.9	30.4	Very faint.
	6301	8	86.0	23.0	19.3	
	6468	11	94.6	21.0	21.8	
	6475	8	8.1	17.0	26.0	
	6520	14	39.0	24.4	18.7	
	6571	4	30.4	9.3	33.4	
	6596	17	10.2	21.8	20.9	Changed inclination.
	6615	2	31.2	32.9	18.5	
	6652	6	63.0	16.0	24.8	
	6691	14	89.3	30.4	12.3	
	6696	3	52.3	29.8	22.0	
	6729	15	11.5	27.0	16.0	
	6731	15	81.0	23.9	19.0	
	6784	4	56.9	17.3	26.3	
	6819	7	75.5	18.0	26.0	
	6832	11	64.6	28.6	16.0	
	6863	5	25.6	28.0	16.4	
	6891	11	67.0	16.5	26.5	
	6918	8	12.0	18.0	26.2	
	6944	12	52.4	30.9	14.4	
	6963	7	75.8	21.7	22.6	
	6996	11	90.7	28.0	19.5	
	7022	16	46.0	20.5	25.2	
	7061	9	54.0	32.0	12.3	
	7084	12	86.9	20.9	25.0	
	7101	6	98.0	29.4	16.9	
	7140	8	9.8	22.5	23.0	
	7189	10	5.8	31.7	14.8	
	7242	10	77.0	18.6	28.0	Faint.
	7256	9	20.0	32.3	14.3	
1873.		*t.*	*d.*	*d.*	*d.*	
Aug. 3	7297	10	55.0	26.0	21.0	
	7320	1	57.0	20.3	27.3	
	7361	4	76.1	25.0	22.8	
	7401	14	82.5	27.9	20.2	
	7444	9	14.0	25.7	22.2	
	7480	11	21.0	25.0	22.3	
	7503	5	48.0	24.7	22.5	
	7521	14	45.6	24.0	23.5	Cloudy.
Aug. 4	7565	5	50.6	24.3	15.5	Air good.
	7581	14	22.7	3.0	37.0	
	7654	17	70.8	22.6	17.3	
	7666	1	63.1	7.4	32.7	
	7621	10	19.8	32.9	16.2	Changed the inclination.
	7641	9	10.0	5.0	35.3	
	7682	12	44.7	23.7	18.0	
	7733	7	26.0	23.0	18.0	
	7757	7	31.0	25.2	15.8	
	7825	12	4.6	30.7	21.0	
	7838	15	53.0	22.0	18.2	
	7857	4	80.9	22.8	17.8	
	7874	6	88.5	23.6	18.0	
	7880	9	46.8	20.3	21.0	Wrong setting.
	Gr.3673	17	49.3	30.0	11.3	
	7951	10	29.8	28.0	18.4	
	7990	6	63.9	20.3	21.0	
	8003	11	39.0	17.9	23.0	
	8039	7	7.0	27.4	14.0	
	8077	8	68.5	37.8	14.8	
	8147	5	42.0	19.8	22.8	
	8188	8	91.0	32.7	9.0	
	Gr.4110	14	83.0	32.7	9.8	
	8290	9	81.0	20.0	14.5	
	8310	15	46.0	14.0	28.6	
	8317	10	36.0	12.5	29.2	
	Gr.4216	5	4.3	24.7	18.0	
	8374	14	69.5	16.6	26.0	
	28	7	60.1	25.0	18.0	
	67	11	30.3	20.3	23.3	
	87	11	44.4	22.0	20.8	
	105	5	70.3	25.0	17.8	
	121	11	52.0	17.3	25.7	
	178	5	38.5	28.8	14.5	
	201	4	40.3	19.0	24.8	
	(*)	9	25.0	15.3	28.0	
	250	15	42.0	27.0	16.3	

(e).—COMPUTATIONS FOR LATITUDE OF COLORADO SPRINGS, COLO.

Date.	No. of pair.	Half sum of declinations.			Corrections.				Latitude.		
					Micr. and refr.		Level.	Merid.			
1872.		°	′	″	′	″	″	″	°	′	″
Aug. 2	1	38	44	17.10	+5	16.52	+8.83	0.00	38	49	42.45
	2	38	52	18.27	−2	36.01	−0.27	0.00			41.99
	3	38	49	12.95	+0	31.01	−3.50	0.00			40.46
	5	38	59	37.08	−9	53.67	−3.63	0.00			39.78
	6	38	51	56.02	−2	12.20	−4.08	+0.30			40.04
	7	38	50	46.29	−1	01.99	−4.84	+0.30			39.76
	8	38	56	09.43	−6	24.60	−5.14	0.00			39.69
	9	38	54	10.47	−4	23.73	−5.36	+0.04			41.42
	10	38	52	02.04	−2	17.35	−2.79	0.04			41.94
	11	38	47	42.43	+2	00.07	−2.60	0.00			39.90
	12	38	54	56.64	−5	11.50	−5.06	0.00			40.08
	13	38	57	20.68	−7	39.54	+1.73	+0.04			42.91
	14	38	53	53.73	−4	16.72	+3.16	0.00			40.17
	15	38	55	37.74	−6	00.15	+2.69	0.00			40.28
	16	38	55	32.12	−5	48.24	−1.10	0.00			42.78
	17	38	51	40.50	−2	00.94	+1.28	0.00			40.84
	18	38	46	22.19	+3	20.26	−1.21	0.00			41.24
	19	38	47	21.61	+2	16.92	+2.59	0.00			41.12
	20	38	47	31.17	+2	08.90	+1.26	0.00			41.33
	21	38	56	20.23	−6	42.34	+4.12	0.00			42.01
	22	38	46	32.79	+3	06.41	+2.28	0.00			41.48
	23	38	50	37.75	−1	00.74	+4.51	0.00			41.52
	24	38	56	41.06	−7	01.60	+2.36	0.00			41.82
	25	38	57	27.43	−7	45.41	−0.55	0.00			41.47
	26	38	54	53.13	−5	14.55	+2.72	0.00			41.30
	27	38	50	43.09	−1	04.59	+1.43	0.00			39.93
	28	38	54	20.20	−4	38.26	+0.06	0.00	38	49	42.00
Aug. 4	28	38	54	20.87	−4	31.89	−6.90	0.00	38	49	42.08
	29	38	58	01.72	−8	16.08	−5.50	0.00			40.14
	30	38	59	19.96	−9	33.94	−6.21	0.00			39.81
	31	38	52	20.47	−2	40.89	+2.67	0.00			42.25
	32	38	52	00.06	−2	20.25	+2.50	0.00			41.39
	33	38	44	07.72	+5	30.66	+2.94	0.00			41.32
	34	38	45	08.56	+4	29.25	+2.83	0.00			40.64
	35	38	45	26.65	+4	09.33	+4.90	0.00			40.88
	36	38	47	50.22	+1	50.91	+1.10	0.00			42.23
	37	38	47	19.18	+2	20.71	+2.28	0.00			42.17
	38	38	48	00.34	+1	39.54	+2.17	0.00			42.05
	39	38	51	24.35	−1	48.42	+5.97	0.00			41.90
	40	38	54	29.04	−4	52.37	+5.50	0.00			42.17
	41	38	53	46.58	−3	04.87	−0.30	0.00			41.41
	42	38	59	08.94	−9	27.21	−0.70	0.00			41.03
	43	38	44	33.51	+5	09.20	−0.74	0.00			41.97
	44	38	48	00.60	+1	41.61	+1.37	0.00			43.58
	45	38	46	41.93	+2	58.41	+2.61	0.00			42.95
	46	38	52	36.09	−2	56.95	+1.05	0.00			41.89
	47	38	44	01.61	+5	39.40	+1.48	0.00			42.49
	48	38	46	33.68	+3	08.59	−0.55	0.00			41.72
	49	38	50	36.07	−0	57.30	+3.40	0.00			42.17
	50	38	52	35.44	−2	56.10	+2.61	0.00			41.95
	51	38	44	10.92	+5	33.52	−4.01	0.00	38	49	40.43
Aug. 5	14	38	53	55.28	−4	14.21	+0.16	0.00	38	49	41.23
	15	38	55	36.54	−5	53.88	−0.23	0.00			42.43
	16	38	55	23.94	−5	41.80	+0.27	0.00			42.41
	17	38	51	41.30	−2	03.04	+4.45	0.00			42.71
	18	38	46	24.00	+3	16.55	+0.80	0.00			41.35
	19	38	47	22.65	+2	18.31	+0.53	0.00			41.49

NOTE.—The example herein has been taken from Special Ast. Rep., 4°, 1874, p. 50, *et seq.*

(*f*).—TIME BY SINGLE ALTITUDE.

Station, Camp 10, near Hamilton, Nev. Date, July 18, 1869. Wheeler, observer.

		°	′	″		
Latitude	= ∠ =	39	15	48.9	Log. r.	
North polar dist.	= Δ =	69	47	06.5	Bar.	......
Name of star	=	Sun's upper limb.			Attd. th.	......
Obs'd doub. alt.	=	114	55	00.0	Det. th.	......
Index error	=		— 3	25.5	Ref. (mean)	37″.2
Doub. alt. cor.	=	114	51	34.5		
Altitude	=	57	25	47.2		
Ref. (Ther. bar)=			— 0	37.2		
True alt. of ✻	= A =	57	25	10.0		

		°	′	″			
∠	=	39	15	48.9	cos. ∠	=	9.8888771
Δ	=	69	47	6.5	sin. Δ	=	9.9695290
A	=	57	25	10.0	cos. ∠ sin. Δ	=	9.8584061
2m	=	165	28	05.4			
m	=	82	44	2.7	cos. m	=	9.1020021
m — A	=	25	18	52.7	sin. (m — A)	=	9.6310263

Cos. m sin. (m — A) = 8.7330284

$$\text{Sin.}^2\, \tfrac{1}{2}\, p = \frac{\text{cos. m sin. (m — A)}}{\text{cos. } \angle \text{ sin. } \Delta} = 8.8746288$$

sin. ½ p = 9.4373146

		°	′	″
½ p	=	15	53	09.79
p in arc	=	31	46	19.58
		h.	m.	s.
p in time	=	2	07	05.30
24ʰ + eq. of time = app. noon	=	24	05	56.10
Mean time = ± p	=	21	58	50.80
Time of obs'n by chron'r	=	9	29	34.68
Chron'r slow of mean time	=		+29	16.12

NOTE.—This form answers for time by single altitude of east and west stars, taken at nearly equal elevations above the horizon and at hour angles from the meridian as nearly equal as possible.

(*g*).—TIME BY EQUAL ALTITUDES OF SUN'S UPPER LIMB.

See page 63, Sextant Observation Book. Station, Camp 10, near Hamilton, Nev. Date, July 28, 1869. Wheeler, observer. Assumed lat., + 39° 15′ 49″. Assumed long., 7h 41m 44s.

		°	′	″
Dec. of sun at Greenwich apparent noon		+18	56	13.7
Hourly variation	−34″.94			
Long	7h.6955			
			−4	28.88
Dec. at apparent noon at station		18	51	44.82
		h.	m.	s.
Eq. of time at Gr. apparent noon		0	06	11.28
Hourly variation	0s.054			
Long	7h.6955		−0	0.42
Eq. of time at apparent noon at station		0	06	10.86
Mean of times of observation a. m		9	35	49.32
Mean of times of observation p. m		13	39	56.56
Difference		4	04	07.24
Sum		23	14	45.88
Half sum		11	37	22.94
Hourly variation in dec. = δ				−34″.94

A	n9.4265	B	9.3623
Log. δ	n1.5433	Log. δ	n1.5433
Log. tang. lat	9.9125	Log. tang. dec	9.5336
+7.63	0.8823	−2.75	n0.4392

	h.	m.	s.
Half sum of times of obs	11	37	22.94
Correction		+0	4.88
Chron. time of app. noon	11	37	27.82
Mean time of app. noon	12	6	10.86
Error of chronometer (slow)	0	28	43.04

(h).—CIRCUM-MERIDIAN ALTITUDES OF ALTAIR (α AQUILÆ).

Station Camp 10, near Hamilton, Nev. Date, July 29, 1869. Wheeler, observer.

No.	Observation 2 altitude.	Time of observation.	Time fr. mer.	Red. to mer.
	° ′ ″	h. m. s.	m. s.	″
1	118 30 00	10 41 01	+6 49.3	91.2
2	118 31 00	10 41 31	6 19.3	78.4
3	118 32 00	10 42 01	5 49.3	66.7
4	118 33 00	10 42 43	5 07.3	51.5
5	118 34 00	10 43 22.7	4 27.6	39.1
6	118 35 00	10 44 20.8	3 29.5	23.9
7	118 36 00	10 45 32	2 18.3	10.4
8	118 37 00	10 47 46	+0 04.3	0.0
9	118 35 30	10 49 53	−2 02.7	8.2
10	118 34 00	10 50 55	3 04.7	18.6
11	118 33 00	10 51 54	4 03.7	32.4
12	118 32 00	10 52 46	4 55.7	47.7
13	118 31 00	10 53 34.6	5 44.3	64.7
14	118 30 00	10 54 25	6 34.7	85.0
15	118 29 00	10 55 10.1	7 19.8	15.6
Sum	492 30	....	....	723.4
Mean	118° 32′ 50″	....	....	48″.23

	h.	m.	s.
Stars RA	19	44	25.72
Long. in time	7	41	43.99
Reduction to sidereal time m. n. at station		1	15.85
Sid. time m. noon at Greenwich	8	24	45.38
Sid. interval past mean noon	11	18	24.49
Retardation—		1	51.14
Mean time of Culmination	11	16	33.35
Chron. slow		28	43.04
Chron. time of Culmination	10	47	50.31

COMPUTATION.

		° ′ ″		
Assumed Lat.	= +	39 15 45.8	+ log. cos.	9.88888
Dec.	= +	8 31 41.2	+ log. cos.	9.99517
				9.88405
Z	=	30 44 04.6	− log. sin.	9.70847
				0.17558
Mean of red	=	48.23	log.	1.68332
1 = 1.00547				0.00237
Correction	= +	72″.63	log.	1.86127

	+	−
Correction	+ 72″.63	
Half index error		−70″.0
Refraction		25.9
Sum	+ 1′ 12″.7	−1′ 35″.9

		° ′ ″
Diff. = total correction	=	− 0 23.2
Half mean of obs'd 2 alt	=	59 16 25.0
True mer. alt.	=	59 16 01.8
Zenith distance	=	30 43 58.2
Dec.	=	8 31 41.2
Lat.	=	39 15 39.4

Log. r. =		1.58058
Bar.	23.113	9.88673
Ther att'd.	64°.4 F.	9.99939
Ther. det'd.	65.2 F.	9.99845
Refraction	25″.88	1.41314

NOTE.—This form is used also in obtaining latitude by circum-meridian altitudes of the Sun.

(*i*).—LATITUDE BY POLARIS.

Sextant No. 8. M. T. Chronometer No. 1283. Station, Camp 10, near Hamilton, Nev. Date, July 28, 1869. Wheeler, observer.

[This reduction is made with the Polaris tables of the British Nautical Almanac (1869), and refraction tables of Ivory (Lee's Tables, Ed. 1853).]

	°	′	″		h.	m.	s.
Mean obsd. 2 alt	79	07	27.3	Time by chron	11	01	07.81
Index error		− 2	20	Chron. slow		28	43.04
Corrected 2d alt	79	05	07.3	Mean time of obs	11	29	50.85
Altitude	39	32	33.6	Diff. of longitude	7	41	43.89
Refraction		− 0	52.7	Mean time at Gr. m. n	19	11	34.74
Corrected alt	39	31	40.9	Acceleration		3	09.18
Subtract 1′		− 1					
Reduced alt	39	30	40.9	Sid. int. past Gr. m. n	11	33	00.03
1st correction		−16	49.9	Sid. time m. n. at place	8	24	45.38
Apparent alt	39	13	51.0	Sid. time of obs	19	57	45.41
2d correction		+ 0	47.4				
3d correction		+ 1	05.9	Log. r .... 70″.06			1.84547
Latitude	39	15	44.3	Barometer 22in.113			9.88673
				Ther. attached .... 64°.4 F.			9.99908
				Ther. detached .... 65°.2 F.			9.99045
				Refraction .... 52″.69			1.72173

LATITUDE BY POLARIS.

Sextant No. 8. M. T. Chronometer No. 1283. Station, Camp 10, near Hamilton, Nev. Date, July 28, 1869. Wheeler, observer.

[The same observations reduced by the later method as given in the American Ephemeris, and the refraction by Bessel's tables.]

	°	′	″		h.	m.	s.
Mean obsd. 2 alt	79	07	27.3	Time by chron	11	01	07.81
Index error		− 2	20	Chron		28	43.04
Corrected 2d alt	79	05	07.3	Mean time of obs	11	29	50.85
Altitude	39	32	33.6	Diff. of longitude	7	41	43.89
Refraction		− 0	52.8	Mean time at Gr	19	11	34.74
Corrected alt	39	31	40.8	Acceleration		3	09.18
Table A	φ −16		00.9	Sid. int. past Gr. m. n	11	33	00.03
B		+ 0	44.3	Sid. time m. n. at place	8	24	45.38
C		+ 0	4.0	Sid. time of obs	19	57	45.41
D		− 0	42.0	App. right ascen'n	1	11	34.31
				Hour angle	−5	13	48.90
					log. α		1.76000
Latitude	39	15	46.2	Barometer 22in.113	log. β^A		−0.10725
				Ther. attached .... 64°.4 F.	log. γ$^\lambda$		−0.01300
				Ther. detached .... 65°.2 F.	log. tan ζ		0.08347
App. declination (δ)	88	38	25.2	Refraction .... 52″.86			1.72312
App. zenith dist. (ζ)	50	28	20				

GEODETIC COMPUTATIONS.*

ADJUSTMENT OF ANGLES.

When the angles at any station are to be obtained from vernier readings, the adjustment is made in the following manner: Take the means of the two vernier readings upon each point included in the observations around the horizon for the reading upon that point; the two readings thus obtained for the point of beginning will usually differ;† when they do not, no corrections are to be applied to the readings. When there is a difference between the two readings upon the point of beginning, this difference is to be divided by the number of points observed upon; the quotient is the correction to be applied to the reading upon the second point. The corrections then increase in arithmetical progression, being applied in order to the consecutive readings. The corrections will all have the + or — sign, according as the measurement around the horizon falls short or exceeds 360°. Each set of observations around the horizon is to be thus corrected when necessary. The angles between the points are then derived by differences between consecutive readings in each set of observations. The means of the values for the different angles thus obtained are taken for the final values of the adjusted angles.

When the measurements at any station are repeated angles, the adjustment is made by the method of least squares, and is as follows: It is evident that between the n objects which surround any point there are necessarily $n-1$ angles. Any angle measured between two points not consecutive is the sum of two or more consecutive angles; hence when all the angles are measured, any measure between points not consecutive gives an equation of condition. As many conditional equations as possible should be formed, care being taken that no one is introduced which is a consequence of two or more already considered. The sum of all the angles at a station should be 360°, and this rigid condition must always enter among the conditional equations. The method of forming the conditional equation is shown in the accompanying example.

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* Special assistance was rendered in the description of the methods employed in the geodetic computations by Lieut. Samuel E. Tillman, Corps of Engineers (now Professor of Geology, etc., at the U. S. Military Academy), and the late F. Kampf, Phd., assistant, U. S. Geographical Surveys.

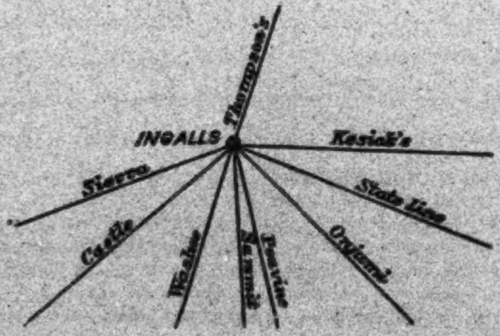
† If this difference is produced by a slipping of the instrument at any particular setting, it will be observed by inspecting the differential angles, and should be corrected without other consideration.

Measured angles at station.

	°	′	″		°	′	″
(1) Castle—Sierra	21	07	27	(4) Peavine—Washoe	12	39	50
(2) Washoe—Castle	21	23	34	(2) Washoe—Castle	21	23	24
	42	31	01		34	03	14
(3) Washoe—Sierra	42	30	49	(5) Peavine—Castle	34	03	12
			12				02
(6) Summit—Washoe	11	47	00	(8) Onjumi—Peavine	25	14	18
(3) Washoe—Sierra	42	30	49	(4) Peavine—Washoe	12	39	50
	54	17	49		37	54	08
(7) Summit—Sierra	54	17	56.5	(9) Onjumi—Washoe	17	53	59
			07.5				09
(10) Onjumi—Summit	26	07	04.5	(11) State Line—Onjumi	16	02	41
(6) Summit—Washoe	11	47	00	(12) McKesick's—State Line	14	06	43
	37	54	04.5		30	09	24
(9) Onjumi—Washoe	37	53	59.0	(13) McKesick's—Onjumi	30	09	29.5
			5.5				5.5
(13) McKesick's—Onjumi	30	09	29.5	(15) Thompson—Onjumi	90	24	54.5
(14) Thompson—McKesick's	60	15	29.1	(10) Onjumi—Summit	26	07	04.5
	90	24	58.6		116	31	59.0
15) Thompson—Onjumi	90	24	54.5	(16) Thompson—Summit	116	31	33
			4.1				26.0

$$0 = +12 + (1) + (2) - (3)$$
$$0 = +2 + (4) + (2) - (5)$$
$$0 = -7.5 + (6) + (3) - (7)$$
$$0 = +9 + (8) + (4) - (9)$$
$$0 = +5.5 + (10) + (6) - (9)$$
$$0 = -5.5 + (11) + (12) - (13)$$
$$0 = +4.1 + (13) + (14) - (15)$$
$$0 = +26 + (15) + (10) - (16)$$
$$0 = +25.5 + (7) + (17) + (16)$$

	°	′	″
(7)	54	17	56.5
(17)	189	10	56.0
(16)	116	31	33.0
	360	00	25.5



These equations of condition, containing a greater number of unknown quantities than there are equations, are to be solved by means of correlatives (Chauvenet, 556, Vol. II). To obtain the coefficients in the normal equations, the following form for the equations of correlatives is to be used:

	1	2	3	4	5	6	7	8	9	Corrections.	Corrected angles.		
											° ′ ″		
1	+1									− 9.68	21 07 27.22	1	Castle—Sierra.
2	+1	+1								− 9.68+ 5.53	21 23 19.85	2	Washoe—Castle.
3	−1		+1							+ 9.68−11.53	42 30 47.15	3	Washoe—Sierra.
4		+1		+1						+ 5.53− 9.03	19 27 46.00	4	Peavine—Washoe.
5		−1								− 5.53	34 03 06.37	5	Peavine—Castle.
6			+1		+1					−11.53+12.56	11 47 01.03	6	Summit—Washoe.
7			−1						+1	+11.53−19.87	54 17 48.16	7	Summit—Sierra.
8				+1						− 9.03	25 14 06.07	8	Onjumi—Peavine.
9				−1	−1					+ 9.03−12.56	37 53 55.47	9	Onjumi—Washoe.
10					+1			+1		+12.56−22.56	26 06 54.48	10	Onjumi—Summit.
11						+1				− 1.27	16 03 30.73	11	State Line—Onjumi.
12						+1				− 1.27	14 06 41.73	12	McKesick's—State Line.
13						−1	+1			+ 1.27− 9.32	30 09 21.45	13	McKesick's—Onjumi.
14							+1			− 9.32	60 15 19.78	14	Thompson—McKesick's.
15							1	+1		+ 9.32−22.56	90 24 41.24	15	Thompson—Onjumi.
16								−1	+1	+22.56−19.87	116 31 35.71	16	Thompson—Summit.
17									+1	−19.87	159 15 36.13	17	Sierra—Thompson.

NOTE.—Rule as many parallel columns as there are equations of condition; to the left of the first column arrange in vertical order the symbols indicating the unknown quantities (usually figures) in the equation of condition. The factors to the unknown quantities, beginning with the first conditional equation, are placed in order in the vertical columns, opposite their respective quantities, and with their proper signs. The numerical terms in the normal equations will be the same as in the conditional equations. The coefficients of the unknown quantities in the normal equations are obtained by multiplying the several factors in every column each into itself and into the corresponding ones in every other, and summing the products of the respective columns. When the unknown quantities are of different weights, an additional column is introduced in the correlates, the weights being placed opposite their respective quantities, and employed in the combination of the factors. The normal equations in this case are:

0=+12	+3.000	+1.000	−1.000	—	—	—	—	—	—
0=+ 2	+1.000	+3.000	—	+1.000	—	—	—	—	—
0=− 7.5	−1.000	—	+3.000	—	+1.000	—	—	—	−1.000
0=+ 9	—	+1.000	—	+3.000	+1.000	—	—	—	—
0=+ 5.5	—	—	+1.000	+1.000	+3.000	—	—	+1.000	—
0=− 5.5	—	—	—	—	—	+3.000	−1.000	—	—
0=+ 4.1	—	—	—	—	—	+1.000	+3.000	−1.000	—
0=+26	—	—	—	—	+1.000	—	−1.000	+3.000	−1.000
0=+25.5	—	—	−1.000	—	—	—	—	−1.000	+3.000

These equations are solved by logarithms, as shown below:

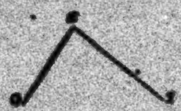
0=+ 8.5	—	—	−0.333	—	—	—	—	−0.333
0=+26					+1.000		−1.000	+3.000
+34.5	—	—	−0.333	—	+1.000	—	−1.000	+2.667
1.5378			9.5224		0.0000		0.0000	(0.4260)
0=+ 4.1	—	—	—	—	—	−1.000	+3.000	−1.000
+12.94	—	—	−0.125	—	+0.375	—	−0.375	
+17.04			−0.125		+0.375	−1.000	+2.625	
1.2315			9.0969		9.5740	0.0000	(0.4191)	
0=− 5.5	—	—	—	—	—	+3.000	−1.000	
+ 6.49	—	—	−0.048	—	+0.143	−0.381		
+ 0.99	—	—	−0.048	—	+0.143	+2.619		
9.9956	—	—	8.6819	—	9.1553	(0.4181)		
0=+ 5.5	—	—	+1.000	+1.000	+3.000	—	—	+1.000
−12.94	—	—	+0.125	—	−0.375	—	+0.375	
0=− 7.44	—	—	+1.125	+1.000	+2.625	—	+0.375	
− 2.435	—	—	+0.018	—	−0.054	+1.042		
− 9.875	—	—	+1.143	+1.000	+2.571	+0.143		
− 0.054	—	—	+0.003	—	−0.008			
− 9.929	—	—	+1.146	+1.000	+2.563			
0.9969	—	—	0.0592	0.0000	(0.4087)			
0=+ 9	—	+1.000	—	+3.000	+1.000			
+ 3.874	—	—	−0.447	−0.390				
+12.874	—	+1.000	−0.447	+2.610				
1.1096	—	0.0000	9.6503	(0.4166)				
0=+ 8.5	—	—	−0.333	—	—	—	—	−0.333
0=− 7.5	−1.000	—	+3.000	—	+1.000	—	—	
+ 1.000	−1.000	—	+2.667	—	+1.000	—	—	−0.333
+ 4.300	—	—	−0.042	—	+0.125		−0.125	
+ 5.300	−1.000	—	+2.625	—	+1.125	—	−0.125	
+ 0.811	—	—	−0.006	—	+0.018	−0.048		
+ 6.111	−1.000	—	+2.619	—	+1.143	−0.048		
+ 0.018	—	—	−0.001	—	+0.003			
+ 6.129	−1.000	—	+2.618	—	+1.146			
+ 4.44	—	—	−0.512	−0.447				
+10.559	−1.000	—	+2.106	−0.447				
+ 2.905	—	+0.171	−0.077					
+12.774	−1.000	+0.171	+2.029					
1.1062	0.0000	9.2330	(0.3073)					
0=+ 2.000	+1.000	+3.000	—	+1.000				
− 4.820	—	−0.383	+0.171					
− 2.820	+1.000	+2.617	+0.171					
− 1.08	+0.084	−0.014						
− 3.90	+1.084	+2.603						
0.5911	0.0351	(0.4155)						

$$
\begin{array}{rrrr}
0=+12.00 & +3.000 & +1.000 & -1.000 \\
+\ 6.29 & -0.493 & +0.064 & \\
\hline
+18.29 & +2.507 & +1.064 & \\
+\ 1.62 & -0.451 & & \\
\hline
+19.91 & +2.056 & &
\end{array}
$$

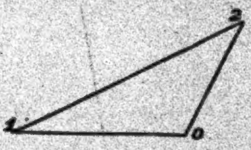
1.2991	κ 1	κ 2	κ 3	κ 4	κ 5	κ 6	κ 7	κ 8	κ 9
0.3131	−9.68	+5.53	−11.53	−9.03	+12.56	−1.27	−9.32	−22.58	−19.87
0.9860									

NOTE.—The solution gives the indicated values for the correlatives, which, multiplied into their corresponding factors in the equations of correlatives, determine the corrections to the unknown quantities, as shown in the example above. After the corrections are applied all equations of condition must be 0=0.

After the angles at all the stations are corrected by either of the above methods, these angles are to be used in the formation of the triangles. The adjustment of the figure composed of several triangles is next accomplished. This adjustment involves what are called both angle and side equations. The first result from the necessity of the three angles of any triangle being equal to 180° + the spherical excess; the side equations from the necessity of the several directions to any one station intersecting in the same vertical line. The conditions are simultaneous, and the angle and side equations must be solved together. The figure for adjustment should include those points which give the best triangles. This result is obtained when each point is occupied and each observed from every other. It usually facilitates work to include 5 to 7 points in a figure. It is also advantageous to embrace triangles in which the smallest angles exist. After all the triangles possible between the points selected are formed, the "spherical excess" (ϵ) of each must be computed; four-place decimals are sufficient. This computation should always be controlled by observing whether the sum of the corrections of two of the triangles of a quadrilateral be equal to the sum of the corrections of the other two into which it can be divided. Each angle is formed by two sights, and is represented by figures, thus: 1. 2. 0. The number at the vertex is always placed in the center; or it may be represented thus: $-\binom{1}{2}+\binom{0}{2}$, the left-hand sight being given



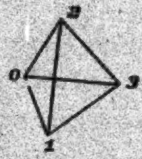
the negative sign. The spherical excess (ε) is computed thus (the side 1—2 being known):



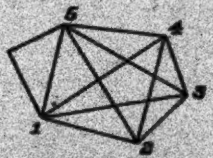
		log 1—2	4.6391	
1.0.2	149° 56′ 20″.74	a. c. sine	0.3002	
0.2.1	19 37 54 .26	sine	9.5263	
2.1.0	10 25 45 .00	sine	9.2577	8.6626
		log 0—1	4.4656	9.6998
	ε=0.58	log 0—2	4.1970	1.4047
				9.7671

The sum of the two sides (0—1) and (0—2) multiplied into sine of included angle and into a constant depending on the latitude gives (ε).

The number of equations.—In every quadrilateral there can be formed three independent triangles; the fourth is a consequence of these three. In each figure one has therefore three angle equations. In forming these equations those triangles should be used with largest error, that is, the maximum difference from 180° + ε. The side equation results from a principle of solid geometry.



Considering (0. 1. 2) as the base, the whole figure, 0. 1. 2. 3., may be considered as the projection of a pyramid, in which the sum of the logarithmic sines of the angles at the base taken in one direction, must be equal to the sum of the logarithmic sines taken in the opposite direction; in this case log. sine 3. 2. 0. + log. sine 3. 0. 1. + log. sine 2. 1. 3. = log. sine 3. 2. 1. + log. sine 0. 1. 3. The vertex must be so chosen as to give the smallest angles in these equations. That station is best for the vertex the sum of whose distances from the other three is a minimum, or that point which is observed more often to than from. To illustrate the method of forming angle and side equations, suppose one has five points at which the angles have been adjusted. Commencing with any point, number them around in order to the right; join 1 with 2, and 2 with 3, and 1 with 3; this gives one angle equation. Then join 4 with each of the other 3 points; this gives two more independent angle equations and one side equation. If, now, the fifth point be joined with the other four, the first two new lines will give a new angle equation, and then each



additional line will give one, and so on for each point brought into the combination. When each point is observed from every other, the number of angle equations will be equal to the sum of the natural numbers from 1 to a number 2 less than the number of points, that is, from 1 to $n-2$ inclusive. After the first three points are joined, it will require three new lines to bring into existence a side equation. As each new point is brought into the figure it *first* requires three lines to introduce a side equation; then each line to the remaining points gives one; so that the number of side equations under above conditions, all points being observed from all others, will be equal to the sum of natural numbers from 1 to $n-3$ inclusive. When each point is not observed from every other, the number of angle and side equations may be known by the following formulæ:

$l-n+1=$number of angle equations.

$l-2n+3=$number of side equations.

$l=$number of lines. (Report of Chief of Engineers, 1872, p. 1046.)

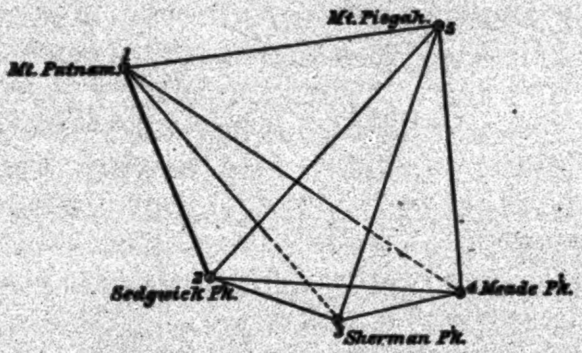
The numerical term in each angle equation is the difference between $180°+\varepsilon$ and the sum of the angle in that triangle, + when the sum of the angles is $>$ and − when $< 180°+\varepsilon$. The numerical term in each side equation is obtained by summing the log. sines of the angles taken in one direction and obtaining the difference between this sum and the sum of the log. sines in the opposite direction. The logarithmic differences of the sines for 1° become the coefficients of the correction to the directions. (Coast Survey Report, 1854, p. 80.)

The following example serves to illustrate the computations employed after the adjustment of angles.

The forms used are entirely the outgrowth of the experience of the survey.

GEODETIC COMPUTATIONS.

Date.	Station.	Angles read—(mean.)	°	′	″	Remarks.
1877. July 16	Meade Peak	Sherman Peak........	......	......	....	Observers, Lieutenant Tillman and Assistant Thompson.
		Sedgwick Peak	10	12	52.14	
		Mount Pisgah	53	2	20.00	
July 23	Sherman Peak	Sedgwick Peak	......	......	....	Observers, Lieutenant Tillman and Assistant Thompson.
		Mount Pisgah	95	0	2.00	
		Meade Peak	66	40	14.00	
Aug. 1st	Mount Pisgah	Meade Peak	......	......	....	Observers, Lieutenant Tillman and Assistant Thompson.
		Sherman Peak	20	4	23.57	
		Sedgwick Peak	22	31	52.80	
		Mount Putnam	39	26	47.86	
Aug. 31	Sedgwick Peak	Mount Putnam........	......	......	....	Observer, Lieutenant Tillman.
		Mount Pisgah.......	59	48	32.50	
		Meade Peak	54	21	45.00	
		Sherman Peak	8	0	21.67	
Sept. 17	Mount Putnam	Mount Pisgah	......	......	....	Observers, Lieutenant Tillman and Assistant Thompson.
		Meade Peak	46	44	27.62	
		Sherman Peak	13	1	33.24	
		Sedgwick Peak	29	56	20.73	



(1) FORMATION OF ANGLE EQUATIONS.

Equation No.	Angles.	Values observed.			Logarithms of sines.	Corrections from least square adjustment.	Corrected angles.	Computation for spherical excess.
	1-2				4.7197			
	2.3.1	(36	47	03.62)	0.2227	−15.69	36 46 47.93	3-2 4.4954
	3.1.2	29	56	20.73	9.5530	+ 4.17	29 56 24.90	3-1 4.8695
	1.2.3	122	16	39.17	9.9271	+11.52	122 16 50.69	sin 2.3.1 9.7773
	3-2				4.4954			constant 1.4043
	3-1			3.52	4.8695			0.5465

(1) FORMATION OF ANGLE EQUATIONS—Continued.

Equation No.	Angles.	Values observed.	Logarithms of sines.	Corrections from least square adjustment.	Corrected angles.	Computation for spherical excess.	
	1-2		4.7197				
	2.4.1	(31 51 55.27)	0.2774	− 1.29	31 51 53.98	4-2	4.7443
	4.1.2	33 57 53.97	9.7472	+ 6.78	33 57 47.19	4-1	4.9573
	1.2.4	114 10 17.50	9.9602	− 5.49	114 10 12.01	sin 2.4.1	9.7226
	4-2		4.7443			constant	1.4043
	4-1	6.74	4.9573				0.8285
I	1-2		4.7197				
	2.5.1	39 28 47.86	0.1967	+18.95	39 29 06.81	5-2	4.9106
	5.1.2	80 42 21.59	9.9942	+ 4.51	80 42 26.10	5-1	4.8531
	1.2.5	59 48 32.50	9.9367	+ 3.95	59 48 36.45	sin 2.5.1	9.8033
	5-2	−18.05	4.9106			constant	1.4043
	5-1	− 9.36	4.8531				0.9713
		−27.41					
	1-3		4.8695				
	3.4.1	(42 4 47.41)	0.1738	− 3.71	42 4 43.70	4-3	4.3960
	4.1.3	13 1 33.24	9.3527	+ 2.61	13 1 35.85	4-1	4.9572
	1.3.4	124 53 43.99	9.9139	+ 0.30	124 53 44.29	sin 3.4.1	9.8262
	4-3		4.3960			constant	1.4043
	4-1	3.84	4.9572				0.5837
	1-3		4.8695				
	3.5.1	62 0 40.72	0.0541	+ 8.71	62 0 49.43	5-3	4.8602
	5.1.3	59 46 0.86	9.9366	+ 0.34	59 46 1.20	5-1	4.8530
	1.3.5	(58 13 29.99)	9.9294	− 9.05	58 13 20.94	sin 3.5.1	9.9459
	5-3		4.8602			constant	1.4043
	5-1	11.57	4.8530				1.0634
	1-4		4.9573				
	4.5.1	82 5 4.29	0.0042	+ 8.26	82 5 12.55	5-4	4.8238
	5.1.4	46 44 27.62	9.8623	− 2.27	46 44 25.35	5-1	4.8530
	1.4.5	(51 10 40.03)	9.8915	− 5.99	51 10 34.04	sin 4.5.1	9.9958
	5-4		4.8238			constant	1.4043
	5-1	11.94	4.8530				1.0769
II	4-2		4.7443				
	2.3.4	161 40 22.00	0.5024	+10.22	161 40 32.22	3-2	4.4956
	3.4.2	10 12 52.14	9.2489	− 2.41	10 12 49.73	3-4	4.3959
	4.2.3	8 6 21.67	9.1492	+17.00	8 6 38.67	sin 2.3.4	9.4976
	3-2	−24.19	4.4956			constant	1.4043
	3-4	− 0.62	4.3959				9.7934
		−24.81					
	5-2		4.9106				
	2.3.5	95 0 8.00	0.0017	+ 0.87	95 0 8.87	3-2	4.4957
	3.5.2	22 31 52.86	9.5834	−10.24	22 31 42.62	3-5	4.8601
	5.2.3	62 28 6.67	9.9478	+ 7.57	62 28 14.24	sin 2.3.5	9.9983
	3-2	7.53	4.4957			constant	1.4043
	3-5	− 5.73	4.8601				0.7584
		+ 1.80					

(1) FORMATION OF ANGLE EQUATIONS—Continued.

Equation No.	Angles.	Values observed.	Logarithms of sines.	Corrections from least square adjustment.	Corrected angles.	Computation for spherical excess.
III	5-2		4.9106			
	2.4.5	83 2 20.00	0.0032	+ 6.02	83 2 26.02	4-2 4.7443
	4.5.2	42 36 16.45	9.8305	−10.69	42 36 5.74	4-5 4.8238
	5.2.4	54 21 45.00	9.9100	− 9.44	54 21 35.56	sin 2.4.5 9.9966
	4-2	21.43	4.7443			constant 1.4043
	4-5	− 9.32	4.8238			0.9692
		+12.11				
IV	5-3		4.8602			
	3.4.5	93 15 12.14	0.0007	+ 5.60	93 15 17.74	4-3 4.3964
	4.5.3	20 42 23.57	9.5355	− 0.45	20 4 23.12	4-5 4.8238
	5.3.4	66 40 14.00	9.9629	+ 9.35	66 40 23.35	sin 3.4.5 9.9993
	4-3	−10.29	4.3964			constant 1.4043
	4-5	− 4.21	5.8238			0.6238
		−14.50				

(2) FORMATION OF SIDE EQUATIONS.

Equation No.	Angles.	Variable directions.	Observed values of angles.	Logarithms of sines.	Variation for 1″.	First correction.	Last 4 places of logarithms.
V	4.2.3	−([illegible])+([illegible])	8 6 21.67	9.1492353	+1.478	39.114	4930.1
	3.1.2	−([illegible])	20 56 20.73	9.5531245	+0.550	24.307	1441.9
	(3.4.1)	−([illegible])+([illegible])+([illegible])−([illegible])	42 4 47.41	9.8261820	+0.233	43.209	1722.8
				8.5285419			8094.8
	3.4.2	−([illegible])+([illegible])	10 12 52.14	9.2487908	+1.169	49.221	7567.0
	1.2.3	+([illegible])	122 16 39.17	9.9270988	−0.133	50.784	0833.6
	4.1.3	−([illegible])+([illegible])	13 1 33.24	9.3529375	+0.910	36.775	9696.5
				8.5288271			8097.1
				−28.52			−2.3
VI	5.3.4	−([illegible])+([illegible])	66 40 14.00	9.9629576	+0.091	23.602	9665.8
	4.1.3	−([illegible])+([illegible])	13 1 33.24	9.3529375	+0.910	36.775	9696.5
	4.5.1	−([illegible])+([illegible])	82 5 4.29	9.9958423	+0.029	12.369	8446.9
				9.3117375			7809.2
	4.5.3	−([illegible])+([illegible])	20 4 23.57	9.5355733	+0.576	22.601	5677.6
	(1.3.4)	−([illegible])+([illegible])+([illegible])−([illegible])+([illegible])−([illegible])	124 53 43.90	9.9139295	−0.147	43.847	9180.4
	5.1.4	−([illegible])+([illegible])	46 44 27.62	9.8622885	+0.198	25.042	2833.8
				9.3117914			7691.8
				−5.39			+117.4
VII	(1.4.5)	+([illegible])−([illegible])+([illegible])−(([illegible])	51 10 40.03	9.8915903	+0.170	34.529	5810.5
	5.2.4	−([illegible])+([illegible])	54 21 45.00	9.9099407	+0.151	34.983	9256.2
	5.1.2	−([illegible])	80 42 21.50	9.9949611	+0.034	26.124	2626.8
				9.7957929			7693.5
	5.1.4	−([illegible])+([illegible])	46 44 27.62	9.8622885	+0.198	25.042	2833.8
	2.4.5	−([illegible])+([illegible])	83 2 20.00	9.9967886	+0.026	28.505	7890.1
	1.2.5	+([illegible])	59 48 32.50	9.9366917	+0.123	35.688	6968.3
				9.7957670			7692.2
				+2.52			+1.3

(3) EQUATIONS OF CONDITION.

I 0=−27.41 −([illegible])+([illegible])−([illegible])+([illegible])
II 0=−24.81 −([illegible])+([illegible])−([illegible])+([illegible])−([illegible])+([illegible])
III 0=+12.11 −([illegible])+([illegible])−([illegible])+([illegible])−([illegible])+([illegible])
IV 0=−14.50 −([illegible])+([illegible])−([illegible])+([illegible])−([illegible])+([illegible])
V 0=−28.525−1.460([illegible])+1.143([illegible])+1.611([illegible])−1.711([illegible])−0.936([illegible])+0.936([illegible])
VI 0=− 5.390+0.763([illegible])−1.108([illegible])+0.345([illegible])+0.238([illegible])−0.238([illegible])−0.118([illegible])−0.429([illegible])+0.547([illegible])
VII 0=+ 2.525−0.368([illegible])+0.334([illegible])+0.151([illegible])−0.274([illegible])+0.026([illegible])−0.026([illegible])−0.170([illegible])+0.170([illegible])

(4) CORRELATIVE EQUATIONS.

([illegible])	......	......	......	......	−1.460	+0.763	......	− 3.277−0.892 = − 4.169
([illegible])	......	......	......	......	+1.143	−1.108	−0.368	− 7.112+0.330 = − 6.782
([illegible])	−1	......	......	......	......	+0.345	+0.334	− 4.534+0.027 = − 4.507
([illegible])	......	+1	......	....	+1.611	......	......	+11.614−0.095 = +11.519
([illegible])	......	−1	+1	......	−1.711	......	+0.151	− 5.830+0.344 = − 5.486
([illegible])	+1	......	−1	....	......	......	−0.274	+ 4.188−0.240 = + 3.948
([illegible])	......	−1	......	......	......	......	......	− 2.574−0.123 = − 2.697
([illegible])	......	+1	......	+1	......	+0.238	......	+ 6.718−0.197 = + 6.521
([illegible])	......	......	......	−1	......	−0.238	......	− 3.144+0.320 = − 2.824
([illegible])	......	+1	−1	......	−0.936	......	+0.026	− 3.796+0.322 = − 3.474
([illegible])	......	−1	......	−1	+0.936	......	......	− 0.889−0.175 = − 1.064
([illegible])	......	......	+1	+1	......	......	−0.026	+ 4.697−0.157 = + 4.540
([illegible])	+1	......	......	......	......	−0.118	−0.170	+ 3.049+0.933 = + 3.982
([illegible])	−1	......	+1	......	......	......	......	− 9.720−0.253 = − 9.973
([illegible])	......	......	......	+1	......	−0.429	......	− 0.099−0.370 = + 0.271
([illegible])	......	......	−1	−1	......	+0.547	+0.170	+ 0.870−0.150 = + 0.720

From the foregoing are formed the following

(5) NORMAL EQUATIONS.

Second computation.	First computation.							
− 1.9	0 = −27.41	+4.000	——	−2.000	——	——	−0.463	−0.778
+ 0.7	0 = −24.81	——	+6.000	−2.000	+2.000	+ 1.450	+0.238	−0.125
+ 0.7	0 = +12.11	−2.000	−2.000	+6.000	+2.000	− 0.775	−0.547	+0.203
− 2.1	0 = −14.50	——	+2.000	+2.000	+6.000	− 0.936	−0.500	−0.196
− 2.3	0 = −28.525	——	+1.450	−0.775	−0.936	+10.713	−2.380	−0.703
+117.4	0 = − 5.39	−0.463	+0.238	−0.547	−0.500	− 2.380	+2.539	+0.636
+ 1.3	= + 2.525	−0.778	−0.125	+0.203	−0.196	− 0.703	+0.636	+0.404

SOLUTION.

The solution of the above equations is made by means of four place logarithms.

0.1139	0.40936	9.8910	9.0969	9.3075	9.2923	9.8470	9.8035	(9.6064)
+117.40	− 5.390	− 0.463	+ 0.238	− 0.547	− 0.500	− 2.380	+ 2.539	
− 2.05	− 3.975	+ 1.225	+ 0.197	− 0.320	+ 0.309	+ 1.107	− 1.002	
+115.35	− 9.365	+ 0.762	+ 0.435	− 0.867	− 0.191	− 1.273	+ 1.537	
2.0520	0.97151	9.8920	9.6385	9.9380	9.2810	0.1048	(0.18667)	
− 2.30	−28.525		+ 1.450	− 0.775	− 0.936	+10.713	− 2.380	
+ 2.26	+ 4.394	− 1.354	− 0.218	+ 0.353	− 0.341	− 1.224	+ 1.107	
− 0.04	−24.131	− 1.354	+ 1.232	− 0.422	− 1.277	+ 9.489	− 1.273	
+ 95.53	− 7.755	+ 0.631	+ 0.360	− 0.718	− 0.158	− 1.054		
+ 95.49	−31.886	− 0.723	+ 1.592	− 1.140	− 1.435	+ 8.435		
1.9800	1.50360	9.8591	0.2020	0.0569	0.1568	(0.9261)		
− 2.10	−14.500		+ 2.000	+ 2.000	+ 6.000	− 0.936	− 0.500	
+ 0.63	+ 1.225	− 0.377	− 0.061	+ 0.098	− 0.095	− 0.341	+ 0.309	
− 1.47	−13.275	− 0.377	+ 1.939	+ 2.098	+ 5.905	− 1.277	− 0.191	
+ 14.33	− 1.164	+ 0.095	+ 0.054	− 0.108	− 0.024	− 0.158		
+ 12.86	−14.439	− 0.282	+ 1.993	+ 1.990	+ 5.881	− 1.435		
+ 16.24	− 5.424	− 0.123	+ 0.271	− 0.194	− 0.244			
+ 29.10	−19.863	− 0.405	+ 2.264	+ 1.796	+ 5.637			
1.4639	1.29804	9.6075	0.3549	0.2544	(0.75105)			
+ 0.70	+12.110	− 2.000	− 2.000	+ 6.000	+ 2.000	− 0.775	− 0.547	
− 0.65	− 1.269	+ 0.391	+ 0.063	− 0.102	+ 0.098	+ 0.353	− 0.320	
+ 0.05	+10.841	− 1.609	− 1.937	+ 5.898	+ 2.098	− 0.422	− 0.867	
+ 65.06	− 5.284	+ 0.430	+ 0.245	− 0.489	− 0.108	− 0.718		
+ 65.11	+ 5.557	− 1.179	− 1.692	+ 5.409	+ 1.990	− 1.140		
+ 12.91	− 4.309	− 0.098	+ 0.215	− 0.154	− 0.194			
+ 78.02	+ 1.248	− 1.277	− 1.477	+ 5.255	+ 1.796			
− 9.27	+ 6.330	+ 0.129	− 0.722	− 0.572				
+ 68.75	+ 7.578	− 1.148	− 2.199	+ 4.683				
1.8373	0.87965	0.0599	0.3422	(0.6705)				
+ 0.70	−24.810		+ 6.000	− 2.000	+ 2.000	+ 1.450	+ 0.238	
+ 0.40	+ 0.781	− 0.241	− 0.039	+ 0.063	− 0.061	− 0.218	+ 0.197	
+ 1.10	−24.029	− 0.241	+ 5.961	− 1.937	+ 1.939	+ 1.232	+ 0.435	
− 32.65	+ 2.651	− 0.216	− 0.123	+ 0.245	+ 0.054	+ 0.360		
− 31.55	−21.378	− 0.457	+ 5.838	− 1.692	+ 1.993	+ 1.592		
− 18.02	+ 6.018	+ 0.136	− 0.300	+ 0.215	+ 0.271			
− 49.57	−15.360	− 0.321	+ 5.538	− 1.477	+ 2.264			
− 11.69	+ 7.978	+ 0.163	− 0.909	− 0.722				
− 61.26	− 7.382	− 0.158	+ 4.629	− 2.199				
+ 32.28	+ 3.558	− 0.539	− 1.033					
− 28.98	− 3.824	− 0.697	+ 3.596					

SOLUTION—Continued.

1.4691	0.58252	9.8432	(0.55582)					
− 1.90	−27.410	+ 4.000	———	− 2.000	———	———	− 0.463	
+ 2.50	+ 4.863	− 1.498	− 0.241	+ 0.391	− 0.377	− 1.354	+ 1.225	
+ 0.60	−22.547	+ 2.502	− 0.941	− 1.609	− 0.377	− 1.354	+ 0.768	
− 57.19	+ 4.644	− 0.378	− 0.216	+ 0.430	+ 0.095	+ 0.631		
− 56.59	−17.903	+ 2.124	− 0.457	− 1.179	− 0.222	− 0.723		
+ 8.18	− 2.732	− 0.062	+ 0.136	− 0.098	− 0.123			
− 48.41	−20.635	+ 2.062	− 0.321	− 1.277	− 0.405			
+ 2.09	− 1.427	− 0.029	+ 0.163	+ 0.129				+ 2.585
− 46.32	−22.062	+ 2.033	− 0.156	− 1.148			− 9.365	−10.085
+ 16.85	+ 1.857	− 0.261	− 0.539			−31.886	+ 9.675	− 0.447
− 29.47	−20.205	+ 1.752	− 0.697		−19.863	− 9.367	+ 1.555	+ 0.657
− 5.62	− 0.741	− 0.135		+ 7.578	− 5.248	+ 5.691	− 2.805	− 0.390
− 35.09	−20.946	+ 1.617	− 3.824	−14.870	+ 8.094	− 3.689	− 0.380	− 3.509
			− 9.030	− 7.860	+ 5.813	− 2.852	− 6.353	+ 3.092
		(0.2086)						
			−12.854	−15.152	−11.204	−42.103	− 7.473	− 8.157
		1.3211	1.1094	1.18047	1.04937	1.62431	0.87350	0.91153
		1.1125	0.55322	0.50905	0.29832	0.6962	0.6868	1.3051
		+12.955	+ 3.574	+ 3.235	+ 1.967	+ 4.991	+ 4.862	+20.190
								+ 1.30
							+115.35	−16.89
						+95.49	+ 16.54	− 1.53
					+29.10	−15.69	+ 5.34	− 0.73
				+68.75	− 8.79	+19.53	+ 3.12	+ 1.45
			−28.98	−24.92	+27.77	+ 4.10	+ 1.41	+ 9.50
			−15.13	−26.97	− 6.47	+10.59	+ 17.21	−65.80
			−44.11	+16.86	+41.61	+114.02	+158.97	−72.70
		1.5452	1.6445	1.2269	1.6192	2.0570	2.2013	1.8615
		1.3366	1.0887	0.5564	0.8682	1.1309	2.0146	2.2561
		+21.70	+12.27	−3.60	−7.38	−13.52	−103.43	+1.7993

The different correlatives are:

	From first computation.	From second computation.	Sum.
a_1 =	+12.955	+0.2170 =	+13.1720
a_2 =	+ 3.574	+0.1227 =	+ 3.6967
a_3 =	+ 3.235	−0.0360 =	+ 3.1990
a_4 =	+ 1.987	−0.0738 =	+ 1.9132
a_5 =	+ 4.991	−0.1252 =	+ 4.8658
a_6 =	+ 4.862	−1.0243 =	+ 3.8377
a_7 =	+20.190	+1.7993 =	+21.9893

The sum of these values introduced in the correlatives gives the resulting corrections of the directions as given before.

The computation of distances, after the final adjustment of figures, consists of the solution of the triangles, and is always checked by duplicate reduction from the common triangles to which any side may belong, plane angles being used.

The following are examples of computations for distances:

Objects.	Spherical angles.			Sph. exc.	Plane angles.			Logarithms.
Putnam-Sedgwick								4.7190887
Sherman Peak	26	46	47.93	1.17	26	46	46.76	0.3457023
Mount Putnam	20	56	33.90	1.17	20	56	32.73	9.5531410
Sedgwick Peak	132	16	41.69	1.18	132	16	40.51	9.8690950
Sherman-Sedgwick								4.6185670
Sherman-Putnam								4.9385110
Putnam-Sedgwick								4.7190887
Meade Peak	31	51	53.98	2.25	31	51	51.73	0.2774280
Mount Putnam	33	58	0.75	2.25	33	57	58.50	9.7471521
Sedgwick Peak	114	10	12.01	2.24	114	10	9.77	9.9601049
Meade-Sedgwick								4.7442867
Meade-Putnam								4.9572080
Putnam-Sedgwick								4.7190887
Mount Pisgah	39	29	6.61	3.12	39	29	3.49	0.1966834
Mount Putnam	90	42	26.10	3.12	90	42	22.98	9.9999616
Sedgwick Peak	49	48	36.45	3.12	49	48	33.33	9.8829927
Pisgah-Sedgwick								4.9160567
Pisgah-Putnam								4.8020088
Putnam-Sherman								4.9385110
Meade Peak	42	4	42.70	1.28	42	4	41.42	0.1738298
Mount Putnam	13	1	35.85	1.28	13	1	34.57	9.3529496
Sherman Peak	124	53	44.29	1.28	124	53	43.01	9.9139130
Meade-Sherman								4.4652902
Meade-Putnam								4.9572080
Putnam-Sherman								4.9385110
Mount Pisgah	63	0	48.43	2.86	63	0	45.57	0.0500141
Mount Putnam	59	46	1.20	2.86	59	45	57.34	9.9365014
Sherman Peak	57	13	20.04	2.95	57	13	17.09	9.9246847
Pisgah Sherman								4.9250265
Pisgah-Putnam								4.8530088
Putnam-Meade								4.9572080
Mount Pisgah	82	5	12.56	3.98	82	5	8.57	0.0041566
Mount Putnam	46	44	25.85	3.98	46	44	21.87	9.8622761
Meade Peak	51	10	34.04	3.98	51	10	30.06	9.8915725
Pisgah-Meade								4.8236023
Pisgah-Putnam								4.8530097
Meade-Sedgwick								4.7442867
Sherman Peak	161	40	32.22	0.21	161	40	32.01	0.5023310
Meade Peak	10	13	40.73	0.21	10	13	40.52	9.2467068
Sedgwick Peak	8	5	47.67	0.20	8	5	47.47	9.1486538
Sherman-Sedgwick								4.4933245
Sherman-Meade								4.3952715
Pisgah-Sedgwick								4.9160567
Sherman Peak	95	0	5.57	1.01	95	0	4.56	0.0016570
Mount Pisgah	22	51	41.72	1.01	22	51	40.71	9.5893512
Sedgwick Peak	62	8	14.34	1.01	62	8	13.33	9.9465169
Sherman-Sedgwick								4.5070649
Sherman-Pisgah								4.8642806

Objects.	Spherical angles.	Sph. exc.	Plane angles.	Logarithms.
Pisgah-Sedgwick				4.[illegible]
Meade Peak	83 2 29.02	2.11	83 2 26.91	0.[illegible]119
Mount Pisgah	42 36 5.74	2.11	42 36 3.63	9.[illegible]151
Sedgwick Peak	54 21 31.56	2.10	54 21 29.46	9.[illegible]218
Meade-Sedgwick				4.744[illegible]
Meade-Pisgah				4.[illegible]
Pisgah-Sherman				4.[illegible]
Meade Peak	93 15 17.74	1.40	93 15 16.34	9.[illegible]
Mount Pisgah	20 4 22.12	1.40	20 4 20.72	9.[illegible]
Sherman Peak	66 40 24.35	1.41	66 40 22.94	9.[illegible]
Meade-Sherman				4.[illegible]
Meade-Pisgah				4.[illegible]

The following examples indicate method of obtaining the latitude, longitude, and azimuth, which are followed by forms for recording the data resulting from the computations:

Azimuth α:	Mount Putnam to Sedgwick Peak	257 45 3.67
Spherical angle:	At Mount Putnam	− 0 42 26.10
Azimuth α'	Mount Putnam to Mount Pisgah	257 2 37.57
δα + 180°		+180 34 55.06
Azimuth (α)	Mount Pisgah to Mount Putnam	77 37 32.63

GEODETIC CO-ORDINATES.

Latitude.					Longitude.		
L:	42 57 7.987		Mount Putnam,	λ:	112 10 9.862		
δL	+ 0 8 26.511			δλ	− 0 51 12.075		
L'	43 5 34.498		Mount Pisgah,	λ'	111 18 57.787		

Computation for latitude:

log. dist. 4.8[illegible]
B 8.5106[illegible]
cos α' − n9.3506[illegible]
log. (I) n2.714[illegible] −517.9723
log. dist.² 9.70[illegible]
C 1.37[illegible]
sin²α' 9.977[illegible]
log. (II) 1.05[illegible] + 11.[illegible]
log. D 2.[illegible]
−506.57 log. [(I)+(II)]² 5.4[illegible]
log. (III) 7.7[illegible] + 0.0[illegible]
log. E 6.1675
sin²α' dist.² 9.6[illegible]
(I) n2.7143
−log. (IV) n8.5[illegible] + 0.0[illegible]
−δL −506.5[illegible]

Computation for longitude:

log. dist. 4.8[illegible]
sin α' n9.9[illegible]
A' 8.5091[illegible]
sec L' 0.136[illegible]
+70
log. (V) n3.4874[illegible]
δλ −3072.0765

Computation for azimuth:

log. (V) n3.4874317
$\sin\left(\frac{L+L'}{2}\right)$ 9.83[illegible] 7.849
$\sec\frac{\delta L}{2}$ 0.000[illegible] n5.[illegible]
log. (VI) n3.3215[illegible] n5.[illegible]
−δα −2095.065
− .0[illegible]

Azimuth α:	Sedgwick Peak to Mount Putnam	157	54	[illegible]
Spherical angle:	At Sedgwick Peak	+ 59	48	36.[illegible]
Azimuth α'	Sedgwick Peak to Mount Pisgah	217	42	36.43
Δα' + 180°		+180	24	35.20
Azimuth (α)	Mount Pisgah to Sedgwick Peak	38	6	26.61

GEODETIC CO-ORDINATES.

Latitude.						Longitude.		
L:	42	30	38.968	Sedgwick Peak, λ:		111	55	20.900
δL	+ 0	34	40.021		δλ	− 0	36	42.178
L'	43	5	24.489	Mount Pisgah,	λ	111	18	37.722

Computation for latitude:

log. dist.	4.9105587	
B	8.5107014	
cos α'	n9.8981520	
log. (I)	n3.3194121	−2085.4097
log. dist.²	9.82112	
C	1.36864	
sin²α'	9.57323	
log. (II)	0.76199	+ 5.7807
log. D	2.3954	
−2080 79 log [(I)+(II)]²	6.6364	
log. (III)	9.0318	+ 0.1062
log. E	6.1550	
sin²α' dist.²	9.3944	
(I)	n3.3194	
−log. (IV)	n8.8718	+ 0.0744
		−δL −2080.8314

Computation for longitude:

log. dist.	4.9105587
sin α'	n9.7859319
A'	8.5091042
sec L'	0.1368603
	−35
log. (V)	n3.3428516
δλ	−2202.1737

Computation for azimuth:

log. (V)	n3.3428516	
$\sin\left(\frac{L+L'}{2}\right)$	9.8321843	7.940
$\sec\frac{\delta L}{2}$	0.0000055	n0.029
log. (VI)	n3.1750414	n7.909
−Δα	−1496.378	
	− .007	

POSITIONS, ETC., OF GEODETIC STATIONS.

[Derived from base at Ogden, Utah, by Lieutenant Tillman, Lieutenant Young, and Mr. Thompson.]

Year.	Station.		Distance in miles.	Azimuth.		Latitude.	
	1	2		1 to 2	2 to 1	1	2
				° ′ ″	° ′ ″	° ′ ″	° ′ ″
1877	Mount Putnam	Sedgwick Peak	32.64	237 45 2.67	157 54 53.96	42 57 7.96	42 30 58.97
1877	Mount Putnam	Mount Pisgah .	43.99	257 2 37.57	77 37 33.62	42 57 7.96	43 5 34.40
1877	Mount Pisgah ..	Sedgwick Peak.	40.38	36 8 26.82	217 43 30.43	43 5 34.40	42 30 58.97
1877	Meade Peak ...	Mount Pisgah .	41.47	175 34 53.29	355 32 21.08	42 29 41.37	43 5 34.40
1877	Sedgwick Peak.	Meade Peak	34.49	273 5 5.90	93 12 27.20	42 30 58.97	42 29 41.37
1877	Meade Peak....	Sherman Peak..	15.47	82 10 37.53	262 7 27.88	42 29 41.37	42 27 52.16
1877	Sedgwick Peak.	Sherman Peak..	19.46	230 11 44.66	100 26 53.62	42 30 58.97	42 27 02.16

Year.	Station.		Distance in miles.	Longitude.		Altitude.	
	1	2		1	2	1	2
					° ′ ″	*Feet.*	*Feet.*
1877	Mount Putnam	Sedgwick Peak.	32.64	112 10 9.00	111 55 30.90	8905.3	9207.2
1877	Mount Putnam.	Mount Pisgah ..	43.99	112 10 9.20	111 18 57.73	8905.3	9694.6
1877	Mount Pisgah .	Sedgwick Peak .	40.38	111 18 57.73	111 55 30.90	9694.6	9207.2
1877	Meade Peak	Sedgwick Peak.	41.47	111 15 10.75	111 18 57.73	10540.9	9694.6
1877	Sedgwick Peak .	Meade Peak ...	34.49	111 55 30.90	111 15 10.75	9207.2	10540.9
1878	Meade Peak...	Sherman Peak..	15.47	111 15 10.75	111 33 11.25	10540.9	9672.0
1877	Sedgwick Peak.	Sherman Peak..	19.46	111 55 30.90	111 33 11.25	9207.2	9672.0

GEOGRAPHICAL POSITIONS BY MAIN AND SECONDARY TRIANGULATION FROM BASES MEASURED AT MAIN ASTRONOMICAL POINTS, AND FROM OTHER TRIGONOMETRIC CONNECTIONS.

[From base, measured at Ogden, Utah, by Dr. F. Kampf, Miles Rock, C. E. and C. J. Kintner.]

Year.	Station.	Atlas Sheet No.	Longitude.	Latitude.	Altitude above sea-level.	Station occupied by—	Remarks.
			° ′ ″	° ′ ″	Feet.		
1877	Mount Putnam	22 D	112 10 8.80	42 57 7.96	[illegible]	Lieutenant Young and Mr. Thompson	Triangulation Sheet No. 11.
1877	Sedgwick Peak	..do..	111 55 30.90	42 30 53.97	9297.2	Lieutenant Tillman	Do.
1877	Sherman Peak	..do..	111 33 11.25	42 27 52.18	9572.0	Lieutenant Tillman and Mr. Thompson	Do.
1877	Meade Peak	..do..	111 15 19.74	42 29 41.87	10540.9	......do......	Do.
1877	Mount Pisgah	..do..	111 16 37.73	43 5 34.40	9594.0	......do......	Do.

The different correlatives are:

From first comp.	From second comp.
$a_1 = -\ 0.596$	-0.0089
$a_2 = +\ 3.133$	-0.0080
$a_3 = +\ 0.072$	-0.0223
$a_4 = -\ 0.719$	$+0.0086$
$a_5 = +\ 8.764$	$+0.0291$
$a_6 = +\ 2.205$	-0.0339
$a_7 = -11.384$	-0.0494
$a_8 = +\ 3.129$	-0.0481
$a_9 = -\ 3.553$	$+0.0436$

The sum of these values introduced in the correlatives give the resulting corrections of the directions as given before.

Cross-sight stations.—To compute the position of a point observed from only two other points, the problem is reduced to the solution of a simple triangle, the two observed angles and included side being the known quantities. The third angle is obtained by difference from 180°, the two remaining sides are then determined approximately, and the spherical excess (e) computed. The operation is then repeated with the new angle. When the station is cross-sighted from three points, the problem becomes the simplest case of the more general problem already given, for adjustment of figure, and involves only one side equation. The sum of the two observed angles in each triangle, taken from 180°, gives the third approximately. The spherical excess (e) and the two unknown sides in each triangle are then computed approximately. The side equation is solved, requiring only one correlative and giving one normal equation. The corrections to the angles thus obtained, introduced at the same time with the spherical excess (*e*), give the determination of distances to the required degree of accuracy. When the point is cross-sighted from more than three stations, all possible triangles should be formed, and the problem is similar to the general case already given. The "three-point" problem is solved by the formula given in "Lee's Tables and Formulæ" (p. 87). The more general form of this problem is shown in "Coast Survey Report," 1864 (p. 116).

The following form indicates the means of computing latitudes and departures:

Camp 37, at railroad crossing, Colorado River, Arizona. To Camp 38, at the Needles, Colorado River, Arizona. Date, September 7, 1875. Gilbert Thompson, computer.

Station.		Distance by Odometer.	Correction in units of distance.	Reduced distance.	Bearings—		Reduced distance from station to station, in miles.
					Magnetic.	True.	
Camp	37	1913	—14	66	S. 31 E.	S. 16¼ E.	0.16
	1	1993	— 3	229	N. 86 E.	S. 79¼ E.	.54
	2	2225	....	167	N. 79 E.	S. 86¼ E.	.39
	3	2392	....	270	S. 35 E.	S. 20¼ E.	.64
	4	2662	—10	201	South.	S. 14¼ E.	.47
	5	2873	....	207	S. 40 E.	S. 25¼ E.	.49
	6	3080	—15	227	S. 17 E.	S. 2¼ E.	.53
	7	3322	....	258	S. 44 E.	S. 29¼ E.	.61
	8	3580	—16	281	S. 33 E.	S. 18¼ E.	.66
	9	3877	— 5	136	S. 36 E.	S. 21¼ E.	.32
	10	4018	— 8	344	S. 41 E.	S. 26¼ E.	.81
	11	4370	— 2	103	S. 18 E.	S. 3¼ E.	.24
	12	4475	— 3	252	S. 23 E.	S. 8¼ E.	.59
	13	4730	....	131	S. 50 E.	S. 35¼ E.	.31
Camp	38	4861	....	....	....	....	6.76
Camp	37	1913	—76 = total correction				0.15
		2948	= total travel				6.94

Camp 37, at railroad crossing, Colorado River, Arizona—Continued.

Station.	Southing.	Easting.	Westing.	Aneroid No. 2007. Feet.	Remarks.
Camp 37	64 64	19 19	....	670	Mag. var. 14° 30′ E.
1	106 42	246 227	....	497	
2	116 10	413 167	....	438	
3	369 253	508 95	....	468	Followed a rough trail.
4	564 195	458	50	678	
5	751 187	547 89	....	589	
6	978 227	557 10	....	640	
7	1203 225	684 127	....	582	426 Odometer revolutions equal one mile.
8	1470 267	772 88	....	565	
9	1597 127	822 50	....	737	
10	1905 308	976 154	....	577	
11	2008 103	982 6	....	672	
12	2257 249	1019 37	....	642	
13	2363 106	1095 76	....	....	
Camp 38	2363	1145	50	....	S. 5.66 miles.
Camp 37	....	50	....	....	E. 2.58 miles.
	2363	1095			

```
                     °  ′  ″
Camp 37.  Long. 114 26 36.98 (by Meander.)
                     2 38.55 — = diff. of Long. for E. 2.58 miles.
                ____________
Camp 38.  Long. 114 23 58.43
                ============
Camp 37.  Lat.   34 42 21.43 (by Meander, checked by sextant obs.)
                     4 35.77 — = diff. of Lat. for S. 5.56 miles.
                ____________
Camp 38.  Lat.   34 37 45.66
```

NOTES.—It is considered preferable to compute the Lat. and Dep. with the number of revolutions instead of the miles; the latter being used in plotting.

When there may be a great number of stations, and their intermediate distances very short, it is more accurate and rapid for plotting to use the total Lat. and Dep. of the station from the point of beginning, as given in the example, by the small figures.

HYPSOMETRIC.

The computations necessary for the determinations of differences of altitude from cistern and aneroid barometer observations are made by referring each set of observations to one or more initial points well established in altitude, at which simultaneous observations have been taken, and by means of the methods pointed out by Bvt. Lieut.-Col. R. S. Williamson, Corps of Engineers, in his treatise on the barometer. (See Professional Papers of the Corps of Engineers, No. 15.) The projection employed, and for which co-ordinates are computed at the Washington office of the survey, as required, is that of a secant cone intersecting the spheroid in latitudes 34° and 44° north; the initial element of the cone being the line joining the points at which the parallels above mentioned are intersected by the 111th meridian of west longitude. The resulting maps admit of conjoining; and the amount of distortion, both in distance and azimuth, for so large an area is less in the aggregate than in the polyconic projection.

The following examples indicate the method of computation of barometric altitudes: (*a*) Transcript of Observations (Transcript from Form I and Form II); (*b*) Aneroid Profiles—Computations (Transcripts from Forms III and IV, and Form V); (*c*) Barometric height determinations.

(a).—METEOROLOGICAL OBSERVATIONS IN THE FIELD, 1878.

[Transcripts from Forms I and II.]

Party No. 1. Division, Utah. Recorded in Book No. 123. F. M. Lee, computer.

Date.	Hour.	Standard cist. barometer No. 1735. Error +.006.						Cistern barometer No. 1767.					Aneroid No. 2.		
		Att'd ther.	Reading.	Correct for error and red. to 32°.	Barometer at 32°.	Hourly correction.	Barometer reduced.	Att'd ther.	Error.	Reading.	Error.		Att'd ther.	Reading.	Error.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Camp No. 28, Toll Gate (Summit Branch), Plumas County, Cal.													
Sept. 20	2 p.m.	60.7	24.684	—.096	24.588	+.023	24.611	......	......	......	......	....	......	......	......
20	9 p.m.	33.2	24.620	—.016	24.604	—.003	24.601	33.5	+0.2	24.612	+.005	....	35.0	24.48	—.124
21	6 a.m.	27.6	24.614	—.004	24.610	—.023	24.587	27.8	+0.2	24.612	+.005	....	30.0	24.47	—.140
21	7 a.m.	34.3	24.626	—.010	24.617	—.030	24.587	34.8	+0.2	24.626	+.005	....	......	......	......
							24.596								
		Forks of the road near bridge over Butt Creek (Aneroid Station, No. 11).													
21	12.15 p.m.	70.6	25.522	—.102	25.420	+.007	25.427	......	......	......	......	......	......	......	......
							25.427								
		Butt Mountain, Plumas County, Cal., instrument 20 feet below summit.													
24	7 a.m.	......	......	—.023	22.557	—.030	22.527	37.5	+0.2	22.580	+.005	......	......	......	......
24	8 a.m.	......	......	—.029	22.573	—.040	22.533	40.0	+0.2	22.606	+.005	......	......	......	......
24	9 a.m.	......	......	—.028	22.580	—.040	22.540	45.0	+0.2	22.618	+.005	......	......	......	......
24	10 a.m.	....	......	—.047	22.587	—.024	22.563	49.5	+0.2	22.634	+.005	......	......	....	......
							22.541								
		Camp No. 29, Deer Creek Meadows, Plumas County, Cal.													
21	9 p.m.	40.4	25.428	—.023	25.405	—.003	25.402	40.8	+.02	25.424	+.005	....	42.0	25.40	—.095
							25.409								
22	7 a.m.	31.3	25.544	—.012	25.532	......	......	31.3	+0.2	25.539	+.005	....	32.0	25.40	—.132
22	2 p.m.	74.3	25.564	—.110	25.454	......	......	75.0	+0.2	25.566	+.005	....	74.0	25.50	—.064
22	9 p.m.	42.0	25.436	—.027	25.409	......	25.495	42.4	+0.2	25.508	+.005	....	44.0	25.50	—.089
23	6 a.m.	27.4	25.472	—.003	25.469	—.023	25.446	27.0	+0.2	25.466	+.005	....	30.0	25.33	—.139
23	7 a.m.	29.7	25.462	—.009	25.453	—.030	25.423	29.8	+0.2	25.460	+.005	......	......	......	......
23	9 p.m.	52.6	25.440	—.063	25.377	—.003	25.374	......	......	......	......	......	54.0	25.28	—.097
							25.414								
24	7 a.m.	35.0	25.499	—.021	25.478	—.030	25.448	......	......	......	......	......	30.0	25.34	—.139
24	8 a.m.	45.8	25.529	—.045	25.484	—.030	25.454	......	......	......	......	......	......	......	......
24	9 a.m.	51.3	25.548	—.058	25.490	—.040	25.450	......	......	......	......	......	......	......	......
24	10 a.m.	57.4	25.504	—.072	25.432	—.024	25.408	....	......	......	......	......	......	....	......
							25.455								

NOTE.—Transcripts to be compared by chief of party with original record, and forwarded, when book is filled, to the rate the observations at each place from those at the next following place by leaving two or more lines between them. On used whatever may have been crowded out of the column of remarks concerning the preceding place of observation. Deity. When two cistern barometers are read together, enter the reading of that one which is the more reliable, or which is by comparison with the reading of the standard, corrected for instrumental error only, and with the reading of its "at rometer at 32° F." The "correction" is plus when the reading is less than that of the standard, and minus when greater. The reductions performed in each case are to be noted in writing at head of column.

(e), METEOROLOGICAL OBSERVATIONS IN THE FIELD, 1878.

[Transcripts from Forms I and II.]

Party No. 1. Division, Utah. Recorded in Book No. 123. F. M. Lee, computer.

Aneroid No. 6.			Thermometers.					Force of vapor.	Rel. humidity.	Clouds.			Rain or snow.			Wind.		Remarks.
			No. 5.		No. 4.													
Att'd ther.	Reading.	Error.	Maximum.	Minimum.	Dry bulb.	Wet bulb.	Difference.			Amount.	Name.	Direction of upper clouds.	Began.	Ended.	Inches.	Direction.	Force.	
14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Camp No. 28, Toll Gate (Summit Ranch), Plumas County, Cal.																		
71.0	24.22	–.268	......	......	65.0	46.3	18.7	....	0.231	0	0	0	...	...	...	W.	8	Louis Seckels, observer.
35.0	24.23	–.274	70.0	......	33.5	31.4	2.1	....	0.780	0	0	0	...	...	...	SW.	2	
30.0	24.23	–.250	......	28.0	28.8	27.4	1.4	....	0.740	0	0	0	...	...	...	W.	2	
26.0	24.27	–.267	......	......	34.2	31.5	2.7	....	0.730	0	0	0	...	...	...	NW.	2	
					40.3				0.637									
Forks of the road near bridge over Butt Creek (Aneroid Station, No. 11).																		
72.0	25.13	–.280			69.8	52.2	17.6	....	0.333	0	0	0	...	...	...	SE.	4	
					69.8				0.333	...	...	...	...	...	...	...	...	
Butt Mountain, Plumas County, Cal., instrument 20 feet below summit.																		
......	......	......	......	......	33.5	29.5	4.0	...	0.612	...	...	...	...	...	...	...	...	Lieutenant Tillman, observer.
......	......	......	......	......	38.5	31.8	6.7	..	0.523	...	...	...	...	...	...	...	...	Psychometer, No. 7.
......	......	......	......	......	42.5	31.5	11.0	....	0.363	...	...	...	...	...	...	...	...	
......	......	......	......	......	47.0	34.0	13.0	....	0.326	...	...	...	...	...	...	...	...	
					40.4				0.456									
Camp No. 29, Deer Creek Meadows, Plumas County, Cal.																		
42	25.16	+.315	......	......	30.5	25.0	4.5	...	0.603	0	0	0	...	...	...	0	0	Louis Seckels, observer.
					30.5				0.603									
32.0	25.20	–.332	......	28.5	33.4	30.2	3.2	....	0.678	0	0	0	...	...	...	0	0	
74.0	25.18	–.274	......	......	71.8	50.0	21.8	....	0.262	0	0	0	...	...	...	W.	4	
44.0	25.15	–.319	76.0	......	43.0	37.3	5.7	....	0.613	0	0	0	...	...	...	0	0	
					49.4				0.518									
30.0	25.12	–.349	......	29.5	28.6	26.8	1.8	....	0.682	0	0	0	...	...	...	0	0	
......	......	......	......	......	31.8	28.2	3.6	...	0.580	3	(*)	SW.	...	...	...	0	0	
......	......	......	75.0	......	52.6	45.0	6.6	...	0.625	0	0	0	...	...	...	W.	4	Cisterns 1707 and aneroid No. 6 on side trip.
					38.0				0.629									
......	......	......	......	30.0	43.2	37.5	5.7	..	0.610	0	0	0	...	...	...	0	0	
......	......	......	......	......	46.6	39.0	7.6	..	0.580	0	0	0	...	...	...	0	0	
......	......	......	......	......	52.0	42.6	10.0	..	0.465	0	0	0	...	...	...	SE.	4	
......	......	......	......	......	57.0	43.8	13.2	.	0.390	0	0	0	...	...	...	SE.	6	
					49.8				0.508									

* Clr. Cum.

Office of the Survey. Fill out, in the field, columns Nos. 1, 2, 3, 4, 9, 11, 14, 15, 17, 18, 19, 20, 24, 25 26, 27, 28, 29, 30, and 31. Sepa-
the first of these lines record in *red ink* the means of the preceding set of observations. On the lines next following re-
scribe each locality in full, using, if necessary, the entire line immediately preceding the set of observations at that local-
more habitually in the party, in column 4, as the standard barometer. The error of the other barometer is to be obtained
tached thermometer" corrected for error. The aneroid errors are to be determined by comparison with the "standard ba-
Column 14 is for recording the reduced readings of the second barometer after all necessary corrections have been made.

(b).—ANEROID PROFILES.—COMPUTATIONS.

[Transcript from Forms III, IV, and V.]

Party, No. 1. Utah section. Recorded in Book No. 61. Date, September 21, 1878. Camp No. 28 to No. 29. Fred. W. Floyd, computer.

Station.	Hour.	Aneroid No. 6.	Cist. bar. No. 1723. Error, +.006.			Correct for error of aneroid.	Correct for bar. oscil.	Total correction.	Corrected readings.	Temperature.	t+t'
		Reading.	Reading.	Att. th.	Bar. at 32°.						
	1	2	3	4	5	6	7	8	9	10	11
	7.00 a. m	24.27	24.630	° 54.2	24.617	....	....	....	....	° 58	....
Camp No. 28	7.20	24.28	....	....	....	+.319	−.036	+.283	24.563	....	132
1	8.00	24.37	....	....	....	+.319	−.039	+.280	24.650	48	132
2	8.45	24.38	....	....	....	+.319	−.040	+.279	24.659	....	132
3	9.20	24.60	....	....	....	+.319	−.035	+.284	24.884	....	132
4	9.30	24.67	....	....	....	+.319	−.052	+.267	24.937	....	132
5	10.00	24.80	....	....	....	+.319	−.024	+.295	25.095	65	132
6	10.20	24.78	....	....	....	+.319	−.022	+.297	25.077	....	132
7	10.40	24.80	....	....	....	+.319	−.020	+.299	25.099	....	132
8	11.00	24.85	....	....	....	+.319	−.017	+.302	25.152	....	132
9	11.30	25.00	....	....	....	+.319	−.007	+.312	25.312	....	132
10	11.50	25.10	....	....	....	+.319	−.000	+.319	25.419	....	132
11	12.15	25.11	25.522	73.6	25.420	+.320	+.008	+.328	25.438	73	132
12	12.55	25.00	....	....	....	+.320	+.016	+.336	25.336	....	132
13	1.10	25.10	....	....	....	+.320	+.019	+.339	25.439	....	132
14	2.00	25.00	....	....	....	+.320	+.023	+.343	25.343	74	132
15	2.45	24.95	....	....	....	+.320	+.026	+.346	25.296	....	132
16	3.20	24.90	....	....	....	+.320	+.030	+.350	25.250	....	132
17	4.10	24.85	....	....	....	+.320	+.032	+.352	25.202	72	132
18	4.35	24.90	....	....	....	+.320	+.031	+.351	25.251	....	132
19	5.20	25.05	....	....	....	+.320	+.028	+.348	25.398	....	132
20	5.45	25.10	....	....	....	+.320	+.026	+.346	25.446	....	132
Camp No. 29	6.00 p. m.	25.15	25.522	62.0	25.470	+.320	....	....	....	64	132

NOTE.—Form to be filled and forwarded to the office in Washington, D. C. Fill out columns 1, 2, 10, and 20 from camp or station, with the State or Territory and number of atlas sheet in which situated, will be entered. Locality can

(b).—ANEROID PROFILES.—COMPUTATIONS.

[Transcript from Forms III, IV, and V.]

Party, No. 1. Utah section. Recorded in Book No. 61. Date, September 21, 1878. Camp No. 28 to No. 29. Fred. W. Floyd, computer.

D_1 (h—H)	First approx. diff. of altitude.	D_2	Second approx. diff. of altitude.	Altitude.	Distribution of error.	Altitude above sea-level.	Diff. of altitude betw'n stations.	Distance in miles.	Remarks.
12	13	14	15	16	17	18	19	20	
23566.9	Altitude by cistern bar.			5426.6		5426.6			Toll Gate, Summit Ranch, Cal, Atlas Sheet 47 A.
23650.6	− 92.7	− 7.0	− 99.7	5326.9	+ 4.4	5331.3	95.3	.931	
23660.3	− 9.6	− 0.7	− 10.3	5316.6	8.8	5325.4	5.9	1.081	
23907.4	−238.2	−18.0	−256.2	5060.4	13.2	5073.6	251.8	1.061	
23984.3	− 76.9	− 5.8	− 82.7	4977.7	17.6	4995.3	78.3	.590	
24128.7	−144.4	−11.0	−155.4	4822.3	22.0	4844.3	151.0	.530	
24109.0	+ 18.8	+ 1.4	+ 20.2	4842.5	26.4	4868.9	24.6	.630	Creek.
24132.9	− 23.0	− 1.7	− 24.7	4817.8	30.8	4848.6	20.3	.583	Creek.
24188.3	− 55.4	− 4.2	− 59.6	4758.2	35.2	4793.4	55.2	.634	
24354.0	−166.3	−12.6	−178.9	4579.3	39.6	4618.9	174.5	1.024	
24465.2	−110.6	− 8.4	−119.0	4460.3	44.0	4504.3	114.6	.689	
24505.4	− 40.2	− 3.0	− 43.2	4417.1	48.4	4465.5	38.8	.292	Forks of road to Soldiers' Meadows.
24381.4	+124.0	+ 9.4	+133.4	4550.5	52.8	4603.3	137.8	.531	
24485.9	−104.5	− 7.9	−112.4	4438.1	57.2	4495.3	108.0	.854	Butt Creek.
24386.7	+ 99.2	+ 7.5	+106.7	4544.8	61.6	4606.4	111.1	1.061	
24338.0	+ 49.7	+ 2.7	+ 52.4	4597.2	66.0	4663.2	56.8	1.704	
24290.3	+ 47.7	+ 3.6	+ 51.3	4648.5	70.4	4718.9	55.7	1.202	
24240.4	+ 49.9	+ 3.8	+ 53.7	4702.2	74.8	4777.0	58.1	1.048	Lost Creek.
24291.3	− 50.9	− 3.9	− 54.8	4647.4	79.2	4726.6	50.4	.758	
24443.5	−152.2	−11.6	−163.8	4483.6	83.6	4567.2	159.4	1.911	
24502.1	− 60.6	− 2.8	− 63.4	4420.2	+87.9	4508.1	59.1	.535	Camp 29, Deer Creek Meadows on Lost Creek.
Altitude of Camp No. 29 by cist. bar.				4508.1				18.243	For comparison.
Error in aneroid profile				−87.9 ft.					

aneroid and odometer books; columns 3 and 4 from meteorological book. In column of "Remarks" the locality of the not be too explicitly given. One day's readings alone should be recorded on each page.

(c).—BAROMETRIC DETERMINATION OF HEIGHTS.—FIELD SEASON, 1878.

Party No. 1. Division, Utah. Lieutenant Tillman, executive officer. F. M. Lee, computer. Observations recorded in books No. 123 and No. 52.

Names of tables, etc.	Computation.	Computation.	Computation.	Computation.
Date, 1878	Sept. 20 and 21.	Sept. 21.	Sept. 24.	Sept 21 to 25.
No. of synchronous obs.	4	1	4	Daily means.
Lower station	Red Bluff.	Red Bluff.	Camp 39.	Red Bluff.
Upper station	38. Toll Gate.	Near bridge over Butt Creek.	Butt Mountain.	39. Deer Creek Meadows.
Bar. at 32° { h =	29.631	29.636	25.405	29.670
Bar. at 32° { H =	24.896	25.427	22.341	25.438
Temperature { t_1 =	52.5	71.0	49.8	72.0
Temperature { t' =	40.3	69.8	40.4	42.4
Temperature { $t + t'$ =	92.8	140.8	90.2	114.4
Humidity { a =	.590	.300	.503	.435
Humidity { a′ =	.637	.323	.456	.532
Humidity { a + a′ =	1.227	.623	.959	.967
Latitude =	40° 05′	40° 05′	40° 05′	40° 05′
D_1 (h) =	29486.1	29081.6	24502.3	28482.0
D_1 (H) =	24592.1	24472.4	21316.1	24534.8
1st approx	4894.0	4609.2	3186.2	3947.2
D_2 =	172.9	312.4	86.1	204.4
2d approx	5066.9	4921.6	3273.3	4152.6
D_3 =	2.3	1.0	1.5	1.6
D_4 =	12.8	11.6	8.7	11.2
D_5 =	0.3	0.1	1.5	0.1
3d approx	5073.2	4925.0	3285.0	4160.7
D_6 =	54.0	44.0	40.0	44.0
D_7 =	12.6	22.4	7.8	14.0
Correct for (a + a′) =	15.4	16.4	7.5	12.4
Diff. of altitude =	5088.6	4553.0	3292.5	4180.1
Alt. of reference station =	338.0	328.0	4518.1 +20.0	338.0
Altitude of station =	5426.6	4881.0	7830.6	4518.1

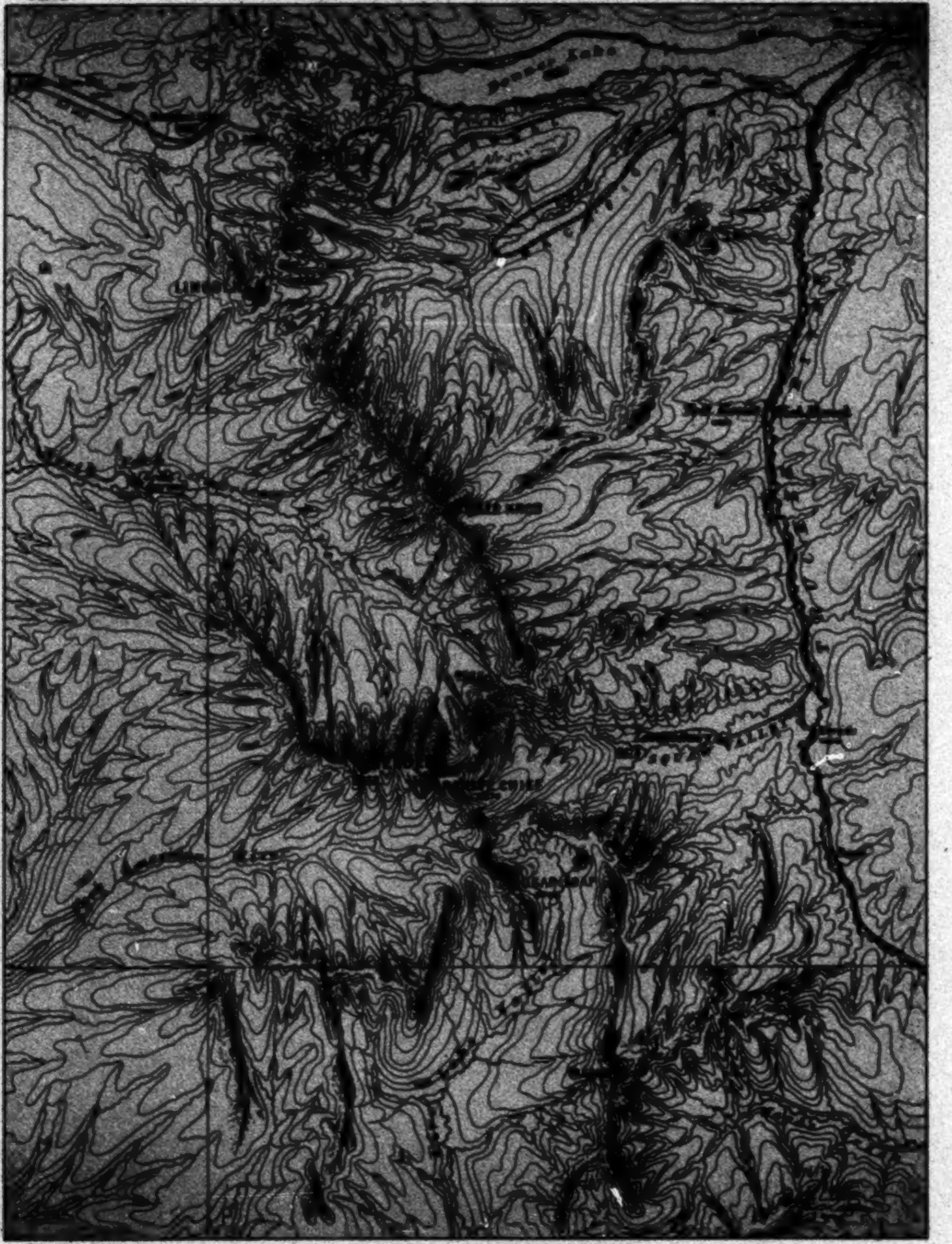
REMARKS.—Barometer 20 feet below summit.

TOPOGRAPHIC.

The topographer's plot is a complete and accurate representation of all the topographic information secured in the field, adjusted to the projection upon which are laid down all the initial check-points upon which the work is based The plots are projected on a scale of 1 inch = 2 miles, with contours at 200 feet interval, subsequent to the computation of latitudes, longitudes, altitudes, departures, distances, azimuths, etc., and

Topography.

VOL. I. GEOGRAPHICAL REPORT.


Donner Lake
VALLEY

Julius Bien, Lith

Scale 1 inch to 2 miles.

Contours 200 feet vertical interval (approx)

(Sample from Plotting Sheet.)

following conventional signs adopted for these sheets. A sample is herewith introduced in the form of an engraved plate.

There is also a special series of conventional signs for the finished atlas sheets.

Upon photographs of these plots the classification of the lands into grades is made, as also upon the completed map when reproduced by photolithography. The final sheets are drawn upon boards upon which paper has long been mounted, and by the modified secant-conic projection on a scale one-third larger than the published representation, *i. e.*, 1 inch to 4 miles and 1 inch to 8 miles, or to such scales as may be decided upon in order that all the advantages resulting to photolithography from a reduction in scale may be secured. The finished map is prepared by office draughtsmen and the work is divided into construction, line-drawing and lettering, and hill-shading. The plotting-sheets are drawn in conjectural contours, and the final maps in both hachures and contours, as also by a combination of the two. To accurately represent the true contour or vertical relief of the ground upon a horizontal projection by conventional signs has long been a desideratum, several methods having been adopted. These resolve themselves into two distinct forms, (1) by contours and (2) by hachures.* The first, for the highest use to which a map may be applied, *i. e.*, for construction purposes, where accurate working profiles are required, is well-nigh indispensable. Such a use presupposes the accurate determination of a large number of points at short distances apart on each contour, an accuracy to which but few if any of the most refined surveys of the world have reached for large areas. The engineer's contour or the contour of precision is, it must be understood, far different from those the result of sketching between points of each contour determined at irregular intervals, that might and should, indeed, be termed, in consequence, conjectural contours

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* The French military engineer, General Noizet de St. Paul, was the first to propose the use of horizontal curves for limited areas, while they were first introduced for generalized areas in the military topographic survey of Hesse-Cassel in 1836 (See H. Ex. Doc. No. 270, 48th Cong., 2d sess., p. 242). Hachures were first introduced by Colonel Lehman, a military geographical engineer, and as full straight lines normal to the adjacent contour of least level and of thickness corresponding to the slope, and modified by General Muffling into broken and sometimes waving in place of straight lines.

Geographical co-ordinates as a means of defining the positions of given points upon the earth's surface were first suggested by Hipparchus, "the founder of astronomy."

The several systems proposed and adopted for the projection of parts or all of the globe upon a map have been supplied by various mathematicians, reference to many of which may be found in Treasury Department Doc. No. 61 (Coast and Geodetic Survey).

The conventional signs employed have been the outgrowth of the wants (principally military and economic) which these basic maps supply.

The line work and lettering at full or other scale, in its artistic merit depends upon whether the maps are to be reproduced by hand engraving or by the various mechanical processes now in vogue.

Contours have to some extent been used in this country as the basis upon which to delineate geology, thereby rendering the coloration of the formations as first in importance. Hachures, or lines normal to the contours, of two kinds, have been employed in certain foreign surveys: (1) of uniform strength and varying number per linear inch; (2) of uniform number per inch and varying strength. These have sometimes been called mathematical contours. In either of these forms they are stiff and inexpressive. The hachures employed upon the final maps of the survey are arbitrarily selected as to direction, number, and strength, allowance being made for light and shade, as best suits the scale where they have been employed. By combining the two (hachures and contours), the former being used only to represent the steepest declivities, the most striking effect is produced, the map is less obscured by heavy lines, and the more practical information, showing routes of communication, lines of drainage, settlements, etc., appears in bolder relief. Neither plan has yet been adopted by the survey, the hachure method having been most used. Each map is made a completed original, ready for reproduction by the camera, and becomes one of the most important records of the survey.

From the computation-forms the longitudes, latitudes, azimuths, altitudes, distances, variations, etc., are entered upon a book record specially prepared, and are held for reference or publication. The geology of the areas represented is shown by a scale of colors selected to indicate the different formations upon the topographic maps as a base. The three originals, (1) topographic, (2) land classification, (3) geologic, of each map are filed as a part of the records of the survey. The reports of operations embrace a description of the annual labors of the survey and discussion of the results. The quarto reports aggregate results in special subjects, as geology, paleontology, etc., prepared by assistants engaged upon the survey, and by others, authorities in their several scientific branches. The methods pursued in the examinations upon data, and collections in mineralogy, geology, zoology, etc., requiring so much comparison and research, can not be reduced to the exactitude of mathematical computations, map projections, and constructions, but are more the result of individual effort after long training and experience.

MODIFIED SECANT CONIC PROJECTION.

The scale (1 inch = 8 miles, or 1:506.880) originally decided upon, after consultation at and upon the express direction and sanction of the Engineer Department, for the construction of atlas sheets of the whole area of 1,443,360 square miles, required practically a new projection, admitting of a minimum of distortion in azimuth and distance consistent with the conjoining of sheets for the whole territory, as well as a single political division or other part thereof. From this requirement there was evolved what has been termed the "modified secant conic projection" theory of projection.

The projection is the development of a secant cone, the directing element of which is the intersection of the central meridian with the parallels of latitude of 34° and 44° north. Along these parallels the degrees preserve upon the map their exact ratio with the actual degrees of longitude. Distances equal to the latitude degrees are laid off along the central meridian and circles drawn through them. The distances measured along the meridians on the map are correct everywhere, and as the meridians from the vertex of the cone to the different points of the developed parallels become right lines the distortion in azimuth is inappreciable.

Formula for deducing x and y, the co-ordinates of curvature:

If we call P the arc of a latitude degree in latitude 34°, and p in latitude 44°, R and r the corresponding radii of the developed cone, we have—

$$\frac{P-p}{R-r}=\frac{P}{R} \text{ or } R=\frac{P(R-r)}{P-p}$$

$P=101{,}037$ yards.* $p=87{,}717$ yards.

$R-r$ (meridional arc from latitude 34° to 44°) $=1{,}214{,}073.7$ yards.

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* Clarke's Spheroid.

Consequently we find—

R=9,209,187.2 yards. r=7,995,113.5 yards.

δ, the angle at the vertex of the developed cone for 1° of longitude, is found by the equation—

$$\frac{\delta}{360^\circ}=\frac{\mathrm{P}}{2\mathrm{R}\pi} \text{ or } \delta=\frac{180\,\mathrm{P}}{\mathrm{R}\pi}=37'\ 43''.$$

As the developed parallels are circular arcs, the co-ordinates of curvature are—

δm, difference of meridians $=x=r \sin \delta$.

δp, difference of parallels $=y=r$ versine $\delta=x$ tang. $\frac{1}{2}\,\delta$.

Greatest error in length, relatively and positively, for an atlas sheet bordering latitude 29°.

The maximum error of construction is at the extreme parallels 29° and 49°.

	Yards.
In latitude 29° one degree of arc is represented by	107,687
In latitude 29° one degree of arc on the globe	−106,564
Error =	1,123

in 107,687, or 1 in 96.

	Miles.
An atlas sheet diagonal, bordering latitude 29° (each sheet embracing 1° 40′ in latitude and 9° 45′ in longitude), is from the above projection	202,248
A great circle connecting the same points on the globe is	−200,805
Hence the error =	1,443

or 1 in 140.

	°	′	″
The azimuth of the diagonal line in projection is	56	17	18
The azimuth of the diagonal line on the globe is	55	45	01
Error in azimuth =		32	17

The following projection tables (or natural scale for 60° in longitude and 21° in latitude) were computed by Assistant Louis Nell, who has otherwise assisted in perfecting the practices under the projection. They exhibit the logarithms of metres, in order to facilitate reduction to any desired scale. The dimensions are given for each degree in latitude from 29° to 49° north latitude, and for a range of 30° in longitude on each side of the central meridian:

MODIFIED SECANT CONIC PROJECTION.

Co-ordinates δm, δp in yards.

Longitude.	Latitude 29°.		Latitude 30°.		Latitude 31°.		Latitude 32°.		Latitude 33°.		Latitude 34°.	
	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.
0												
1	107, [illegible]	[illegible]	106, 337	[illegible]	105, 027	[illegible]	103, [illegible]	[illegible]	102, [illegible]	[illegible]	101, [illegible]	534
2	215, [illegible]	2, [illegible]	212, 701	2, 224	210, 041	2, [illegible]	207, [illegible]	2, 275	204, 719	2, [illegible]	202, [illegible]	2, 217
3	[illegible]	5, 316	318, 019	5, [illegible]	315, [illegible]	5, 125	311, [illegible]	5, 119	307, [illegible]	5, [illegible]	303, 057	4, [illegible]
4	430, 617	9, 450	425, [illegible]	9, 226	419, [illegible]	9, 227	414, [illegible]	9, 100	[illegible]	[illegible]	[illegible], 015	[illegible]
5	538, 176	14, [illegible]	531, 547	14, [illegible]	524, [illegible]	14, [illegible]	516, [illegible]	14, 216	511, [illegible]	14, [illegible]	[illegible]	13, [illegible]
6	645, [illegible]	21, [illegible]	637, [illegible]	[illegible]	628, 717	20, 734	621, 741	20, 471	613, 764	[illegible]	[illegible]	19, 946
7	753, [illegible]	28, [illegible]	743, 706	28, [illegible]	734, 470	28, 216	728, 176	27, [illegible]	715, 971	27, [illegible]	706, [illegible]	27, 145
8	860, 404	37, 702	849, 779	37, 317	[illegible], 151	[illegible]	823, [illegible]	[illegible]	817, [illegible]	36, 917	807, [illegible]	[illegible], 450
9	967, [illegible]	47, 817	955, 675	47, 221	943, 728	[illegible]	931, 700	[illegible]	919, 814	43, 446	907, 857	44, [illegible]
10	1, 074, 72[illegible]	[illegible], 015	1, 061, 456	[illegible]	1, 048, 181	57, 597	1, 034, [illegible]	[illegible]	1, 0[illegible]	[illegible]	1, [illegible]	53, 370
11	1, 181, 703	71, [illegible]	1, 167, [illegible]	70, 512	1, 152, 612	[illegible]	1, 137, 915	[illegible], 765	1, 122, 315	67, [illegible]	1, 106, 712	[illegible]
12	1, 288, [illegible]	84, 944	1, 272, 022	[illegible]	1, 256, 796	82, [illegible]	1, 240, 730	81, 797	1, 224, [illegible]	[illegible], 747	1, 208, [illegible]	79, [illegible]
13	1, 395, 212	[illegible], 967	1, 377, 981	[illegible]	1, 360, 74[illegible]	97, [illegible]	1, 343, [illegible]	95, 974	1, 326, 374	94, 742	1, 309, [illegible]	[illegible], 810
14	1, 501, 721	115, [illegible]	1, 482, 170	114, [illegible]	1, 464, 687	112, 794	1, 446, 675	111, 276	1, 427, 821	109, [illegible]	1, 409, [illegible]	108, 429
15	1, 608, [illegible]	132, 617	1, 588, 191	130, [illegible]	1, 568, [illegible]	129, [illegible]	1, 548, 464	127, 768	1, 528, 596	126, [illegible]	1, 508, 724	124, 426
16	1, 714, 184	150, 643	1, 693, 015	148, 979	1, 671, 842	147, 116	1, 650, [illegible]	145, 256	1, 629, 486	143, [illegible]	1, 608, [illegible]	141, 535
17	1, 820, 113	170, [illegible]	1, 797, [illegible]	168, 126	1, 775, 154	[illegible], 022	1, 752, [illegible]	162, [illegible]	1, 730, 181	161, [illegible]	1, 707, [illegible]	159, 716
18	1, 925, [illegible]	190, 779	1, 902, [illegible]	188, [illegible]	1, 878, [illegible]	186, 607	1, 854, 401	183, 710	1, 830, 607	181, [illegible]	1, 806, [illegible]	178, [illegible]
19	2, 031, [illegible]	212, 4[illegible]	2, 006, 214	209, [illegible]	1, 981, 126	207, [illegible]	1, 956, [illegible]	204, 614	1, 930, [illegible]	201, [illegible]	1, 905, [illegible]	199, [illegible]
20	2, 136, [illegible]	235, 251	2, 110, 148	232, 445	2, 08[illegible]	[illegible]	2, 057, [illegible]	226, [illegible]	2, 030, [illegible]	223, 723	2, 004, [illegible]	220, 314
21	2, 241, [illegible]	259, [illegible]	2, 213, [illegible]	256, 163	2, 186, 141	252, 961	2, 158, 480	249, 737	2, 130, 750	246, [illegible]	2, 103, [illegible]	243, 347
22	2, 346, 215	282, [illegible]	2, 317, 246	278, 977	2, 28[illegible]	275, 466	2, 259, 276	271, [illegible]	2, 230, 297	268, [illegible]	2, 201, 284	265, 018
23	2, 450, [illegible]	310, [illegible]	2, 420, 375	307, 019	2, 390, 104	303, 171	2, 359, [illegible]	299, 331	2, 329, [illegible]	295, 490	2, 299, [illegible]	291, 640
24	2, 554, 767	338, 307	2, 523, 217	334, 129	2, 491, 661	330, 051	2, 460, 106	325, 771	2, 428, [illegible]	321, [illegible]	2, 396, [illegible]	317, 411
25	2, 658, [illegible]	366, [illegible]	2, 625, 736	362, 375	2, 592, 918	357, 943	2, 560, 676	353, 311	2, 527, 228	348, 777	2, 494, 834	344, 2[illegible]
26	2, 762, [illegible]	395, 045	2, 727, 978	391, 744	2, 69[illegible]	386, 445	2, 659, 749	381, 945	2, 625, 414	377, 045	2, 591, 462	372, 353
27	2, 865, 230	427, 577	2, 829, 874	422, 296	2, 794, 488	417, 015	2, 758, 067	411, 738	2, 722, 686	406, 469	2, 686, 279	401, 168
28	2, 968, [illegible]	459, 512	2, 931, 429	453, [illegible]	2, 894, 787	448, 163	2, 858, 101	442, 486	2, 821, 426	436, [illegible]	2, 784, 731	431, 120
29	3, 070, 546	492, [illegible]	3, 032, [illegible]	486, 554	2, 994, 76[illegible]	480, 470	2, 956, 770	474, 384	2, 918, [illegible]	468, 286	2, 880, [illegible]	462, 210
30	3, 172, 641	526, 887	3, 133, [illegible]	520, 361	3, 094, 277	513, 873	3, 055, [illegible]	507, 364	3, 015, 695	500, 854	2, 976, 670	494, 343

MODIFIED SECANT CONIC PROJECTION—Continued.

Longitude.	Latitude 35°.		Latitude 36°.		Latitude 37°.		Latitude 38°.		Latitude 39°.	
	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.
°										
1	99,704	547	98,373	540	97,013	533	95,710	525	94,378	518
2	199,366	2,189	196,734	2,159	195,071	2,130	191,408	2,100	188,745	2,071
3	299,065	4,922	295,073	4,858	291,075	4,791	287,084	4,725	283,089	4,659
4	398,696	8,750	393,373	8,633	388,049	8,516	382,724	8,399	377,399	8,282
5	498,290	13,670	491,630	13,480	484,974	13,305	478,318	13,120	471,662	12,940
6	597,835	19,685	589,838	19,430	581,860	19,157	573,850	18,895	565,871	18,632
7	697,307	26,786	687,948	26,430	678,697	26,073	669,335	25,715	660,010	25,357
8	796,690	34,980	785,990	34,516	775,351	34,048	764,712	33,581	754,071	33,114
9	895,957	44,267	883,995	43,676	871,973	43,085	860,007	42,494	848,040	41,903
10	995,063	54,646	981,776	53,911	968,439	53,182	955,190	52,452	941,907	51,723
11	1,094,107	66,161	1,079,499	65,218	1,064,890	64,336	1,050,276	63,453	1,035,661	62,570
12	1,193,029	78,648	1,177,081	77,598	1,161,180	76,547	1,145,237	75,497	1,129,290	74,446
13	1,291,739	92,279	1,274,548	91,067	1,257,292	89,815	1,240,030	88,582	1,222,784	87,349
14	1,390,449	106,993	1,371,880	105,084	1,353,273	104,135	1,334,703	102,700	1,316,120	101,277
15	1,488,880	122,737	1,468,973	121,147	1,449,066	119,560	1,429,306	117,968	1,409,318	116,372
16	1,587,117	139,661	1,565,937	137,798	1,544,734	136,081	1,523,537	134,084	1,502,336	132,300
17	1,685,195	157,612	1,662,694	155,507	1,640,101	153,406	1,617,604	151,296	1,595,179	149,196
18	1,783,067	176,686	1,759,261	174,379	1,735,469	171,980	1,711,626	169,561	1,687,818	167,202
19	1,880,720	196,737	1,855,615	194,116	1,830,263	191,488	1,805,983	188,855	1,780,360	186,227
20	1,978,150	217,895	1,951,748	214,996	1,925,333	212,089	1,898,912	209,176	1,872,490	206,266
21	2,075,352	240,149	2,047,664	236,966	2,019,930	233,780	1,992,213	230,582	1,964,490	227,314
22	2,172,306	263,527	2,143,266	259,695	2,114,267	256,343	2,085,374	251,951	2,056,236	247,537
23	2,268,968	287,897	2,238,667	283,964	2,208,365	280,121	2,178,064	276,277	2,147,775	272,433
24	2,365,301	312,290	2,333,889	308,046	2,302,223	304,385	2,270,632	300,092	2,239,035	296,497
25	2,461,316	338,700	2,428,674	334,173	2,395,752	330,087	2,362,807	326,100	2,330,026	321,988
26	2,557,344	367,241	2,523,201	362,558	2,489,051	358,494	2,454,890	353,339	2,420,735	347,023
27	2,652,900	395,368	2,617,447	390,595	2,582,022	385,310	2,546,591	380,023	2,511,154	374,734
28	2,748,069	425,451	2,711,378	419,770	2,674,661	414,089	2,637,979	408,407	2,601,279	402,724
29	2,843,038	456,121	2,804,981	450,003	2,767,018	443,941	2,729,040	437,849	2,691,078	431,756
30	2,937,467	487,831	2,898,248	481,318	2,859,023	474,804	2,819,790	468,288	2,780,569	461,772

MODIFIED SECANT CONIC PROJECTION—Continued.

Longitude.	Latitude 40.°		Latitude 41°.		Latitude 42°.		Latitude 43°.		Latitude 44°.	
	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.
°										
1	[illegible], 040	310	91, 714	[illegible]	[illegible]	[illegible]	[illegible], 646	[illegible]	87, 718	481
2	186, 081	2, 043	183, 416	2, 012	180, 751	1, [illegible]	[illegible]	1, [illegible]	175, [illegible]	1, [illegible]
3	279, [illegible]	4, [illegible]	275, 097	4, 025	271, 190	4, [illegible]	267, 102	4, [illegible]	[illegible], 164	4, [illegible]
4	372, 072	8, 166	366, 744	8, 040	361, 416	7, [illegible]	[illegible]	7, 815	[illegible], 756	7, [illegible]
5	465, [illegible]	12, 759	458, 348	12, 575	451, [illegible]	12, [illegible]	445, 037	[illegible]	[illegible]	12, [illegible]
6	557, [illegible]	18, [illegible]	549, [illegible]	18, 106	541, [illegible]	17, 943	[illegible], 915	17, [illegible]	[illegible]	17, 316
7	650, [illegible]	25, [illegible]	641, 375	24, 641	632, 059	24, 253	[illegible]	[illegible]	613, 416	[illegible], 567
8	743, 438	32, 647	732, 782	32, 179	722, 133	31, 712	711, [illegible]	31, 244	[illegible]	[illegible], 776
9	836, 071	41, 312	824, [illegible]	40, 729	812, 135	40, 128	800, 149	[illegible]	788, 171	[illegible], 914
10	928, 613	50, [illegible]	915, 216	[illegible]	902, 017	49, 531	[illegible], 716	[illegible]	875, 412	[illegible], 070
11	1, 021, 044	61, 097	1, 006, 425	[illegible]	991, 801	[illegible]	977, 175	[illegible]	[illegible], 547	[illegible]
12	1, 113, 351	73, [illegible]	1, 097, 400	72, 348	1, 081, 435	71, 294	1, 065, 517	[illegible]	1, [illegible]	[illegible], 191
13	1, 205, 535	86, 110	1, 188, 260	84, [illegible]	1, 170, 990	[illegible]	1, 153, [illegible]	[illegible]	1, [illegible]	81, 183
14	1, 297, 554	[illegible], 848	1, 278, 974	98, 413	1, 260, 301	[illegible]	1, 241, [illegible]	[illegible]	1, 223, 216	94, 137
15	1, 389, 430	114, 567	1, 369, 531	112, 940	1, 349, 633	111, 926	1, 329, 730	[illegible]	1, [illegible]	[illegible]
16	1, 481, 131	130, [illegible]	1, 459, 983	128, [illegible]	1, 438, 711	[illegible]	1, 417, 495	124, 735	1, [illegible], 276	[illegible], 967
17	1, 572, 660	147, 067	1, 550, 140	144, [illegible]	1, 527, 637	[illegible], 674	1, [illegible]	140, 707	1, [illegible]	[illegible]
18	1, 663, 996	164, [illegible]	1, 640, 160	162, [illegible]	1, 616, [illegible]	160, 121	1, [illegible]	157, [illegible]	1, [illegible]	[illegible]
19	1, 755, 120	183, [illegible]	1, 730, [illegible]	180, 979	1, 704, [illegible]	178, 341	1, 678, [illegible]	175, 711	1, [illegible]	[illegible]
20	1, 846, 030	203, 254	1, 819, 628	[illegible]	1, 793, [illegible]	197, [illegible]	1, 766, 745	194, 617	1, 740, 297	[illegible]
21	1, 936, 701	224, 165	1, 909, 061	[illegible]	1, 881, [illegible]	217, [illegible]	1, [illegible], 351	214, 477	1, [illegible]	211, [illegible]
22	2, 027, 224	244, 060	1, [illegible]	[illegible]	1, [illegible], 173	237, 073	1, 940, [illegible]	[illegible], 877	1, 911, [illegible]	[illegible]
23	2, 117, 469	268, 567	2, 087, [illegible]	264, 743	2, 056, 816	260, [illegible]	2, 026, 485	257, [illegible]	1, [illegible], 149	[illegible]
24	2, 207, 436	292, 313	2, 175, 824	288, 127	2, 144, 211	[illegible], 041	2, 112, [illegible]	[illegible], 754	[illegible]	[illegible]
25	2, 297, 130	317, 023	2, 264, 346	312, 494	2, 231, 349	307, [illegible]	2, 198, 444	[illegible]	2, [illegible]	[illegible], 841
26	2, 386, [illegible]	342, 737	2, 352, [illegible]	337, [illegible]	2, 318, 210	[illegible], 801	2, 284, [illegible]	[illegible]	[illegible]	[illegible]
27	2, 475, 711	[illegible], 445	2, 440, 261	364, 155	2, 404, [illegible]	[illegible]	2, [illegible], 343	[illegible], 573	2, [illegible], 975	[illegible]
28	2, 564, 565	[illegible]	2, 527, [illegible]	391, 354	2, 491, [illegible]	[illegible]	2, 454, 371	[illegible]	2, 417, [illegible]	374, [illegible]
29	2, 653, [illegible]	425, [illegible]	2, 615, 101	419, 567	2, 577, [illegible]	418, 471	2, [illegible], 163	407, 374	2, 501, [illegible]	401, 273
30	2, 741, [illegible]	455, 254	2, 702, 034	448, 735	2, [illegible], 754	442, 216	[illegible]	[illegible]	2, [illegible]	429, 171

MODIFIED SECANT CONIC PROJECTION—Continued.

Longitude.	Latitude 45°.		Latitude 46°.		Latitude 47°.		Latitude 48°.		Latitude 49°.	
	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.	δm.	δp.
°										
1	86,392	474	85,040	467	83,715	460	82,381	452	81,047	445
2	172,784	1,896	170,067	1,866	167,430	1,837	164,733	1,807	162,095	1,777
3	259,165	4,264	255,105	4,199	251,104	4,132	247,102	4,067	243,100	4,001
4	345,434	7,581	340,093	7,464	334,729	7,347	329,424	7,230	324,088	7,113
5	431,706	11,844	425,030	11,661	418,373	11,478	411,706	11,295	405,067	11,112
6	517,929	17,053	509,922	16,790	501,896	16,527	493,980	16,263	485,998	16,000
7	604,093	23,208	594,767	22,850	585,440	22,493	576,111	17,581	566,770	21,775
8	690,183	30,308	679,529	29,841	668,873	29,374	658,214	28,905	647,553	28,436
9	776,191	38,352	764,209	37,760	752,225	37,169	740,236	36,576	728,316	35,984
10	862,106	47,339	848,797	46,609	835,486	45,878	822,173	45,147	808,958	44,416
11	947,917	57,269	933,284	56,385	918,648	55,501	904,030	54,616	889,567	53,731
12	1,033,613	68,139	1,017,657	67,087	1,001,698	66,035	985,798	64,982	969,770	63,930
13	1,119,185	79,949	1,101,908	78,715	1,084,628	77,481	1,067,346	76,246	1,050,067	75,011
14	1,204,623	92,696	1,186,027	91,266	1,167,426	89,836	1,148,836	88,403	1,130,217	86,971
15	1,289,916	106,381	1,270,003	104,739	1,250,067	103,098	1,230,167	101,453	1,210,243	99,810
16	1,375,053	121,000	1,353,826	119,133	1,332,586	117,266	1,311,380	115,395	1,290,120	113,529
17	1,460,026	136,552	1,437,486	134,444	1,414,944	132,339	1,392,307	130,227	1,369,843	128,116
18	1,544,820	153,036	1,520,973	150,674	1,497,121	148,311	1,473,265	145,947	1,449,401	143,569
19	1,629,431	170,449	1,604,277	167,818	1,579,119	165,186	1,553,966	162,554	1,528,768	159,921
20	1,713,845	188,789	1,687,388	185,875	1,660,926	182,960	1,634,430	180,045	1,607,950	177,129
21	1,798,052	208,055	1,770,295	204,843	1,742,534	201,631	1,714,767	198,416	1,686,983	195,204
22	1,882,044	228,243	1,852,990	224,720	1,823,932	219,567	1,794,880	216,096	1,765,790	213,966
23	1,965,809	249,351	1,935,462	245,502	1,905,110	241,653	1,874,702	237,801	1,844,390	233,940
24	2,049,338	271,377	2,017,700	267,188	1,986,059	262,989	1,954,411	258,807	1,922,765	254,615
25	2,132,618	294,318	2,099,697	289,775	2,066,769	285,231	2,033,878	280,683	2,000,892	276,139
26	2,215,643	318,173	2,181,439	313,260	2,147,230	308,347	2,113,014	303,431	2,078,709	298,519
27	2,298,401	342,936	2,262,920	337,641	2,227,433	332,365	2,191,820	327,046	2,156,425	321,800
28	2,380,881	368,604	2,344,128	362,913	2,307,367	357,232	2,270,400	351,530	2,233,833	345,896
29	2,463,076	395,176	2,425,053	389,076	2,387,024	382,974	2,348,987	376,872	2,310,980	370,787
30	2,544,974	422,649	2,505,687	416,124	2,466,393	409,509	2,427,093	403,072	2,387,770	396,543

Meridional arcs.		Meridional arcs.		Meridional arcs.	
Latitude.	Yards.	Latitude.	Yards.	Latitude.	Yards.
°		°		°	
29	121,217.1	36	121,354.5	43	121,502.9
30	121,235.8	37	121,375.2	44	121,524.5
31	121,254.6	38	121,396.2	45	121,546.1
32	121,274.1	39	121,417.3	46	121,567.7
33	121,293.8	40	121,438.5	47	121,589.2
34	121,313.7	41	121,459.9	48	121,610.8
35	121,334.1	42	121,481.4	49	121,632.3

APPENDIX D.

NOTES ON THE SURVEY AND DISPOSAL OF THE PUBLIC LANDS.

(With map.)

The area embraced in the territory of the United States, obtained by treaty, conquest, cession of States, and purchase, other than that belonging to the original thirteen States, has been denominated "public domain" and the "national domain." The former is estimated to embrace 2,489,280 square miles (including Alaska, 577,390 square miles), while the latter is increased by 404,955.91 square miles, making a total of 2,894,235.91 square miles, by the annexation of Texas and the land purchase from that State. (See pp. 10, 11, and 13, Public Domain.)

The land surveyed within this territory, according to the records of the General Land Office, to June 30, 1886, was 971,174,878 acres, while that disposed of at same date is reported as 672,176,026 acres.*

The area then remaining unsurveyed was 844,329,269 acres,† while that undisposed of up to June 30, 1886, was approximately 1,144,604,734 acres.

This is a general estimate, and embraces all that reported as unsurveyed and as undisposed of from that which is surveyed, and includes all Indian and other reservations, unsurveyed private land claims, surveyed private land claims in Arizona, California, Colorado, and New Mexico, school lands, unsurveyed railroad, swamp-land, and other grants, 273,272,475 acres reported as undisposed of (June 30, 1886) but surveyed, and all of Alaska and the public land strip, aggregating 373,202,240 acres. The General Land Office has no available data for estimating the areas embraced in the several classes above mentioned. In the above are inclosed the large mountain and desert tracts, unsurveyed rivers and lakes, and much permanently unproductive and barren land, it being impossible to state even approximately the actual amount of productive and useful land available for disposition.

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* The estimated disposition of the public domain under various laws from its origin to June 30, 1883, is given on p. 519, Public Domain, ed. 1883, under various heads, as follows: Cash sales, land bounties, State selections, salines, town sites; railroad, canal, and wagon-road grants; mineral lands, homesteads, scrip, coal lands, stone and timber, swamp and overflowed lands, educational, timber culture, and as desert lands.

† This includes all of Alaska, estimated at 369,529,600 acres.

The cost of the survey and service of the disposal of the public lands, involving all cash receipts on account of the same from the commencement to the 30th June, 1883, was $351,981,160.32, while the net cash receipts therefrom to the same date had been $225,552,675.23, thus showing that the public or national domain had cost to that date in cash $120,428,484.89 more than has been realized. (See diagram, p. 530, Public Domain, ed. 1883, and for statistics pp. 1–21, Public Domain.)

Independent of the above, the cost to the Government of acquiring, disposing of, and rendering available this great domain is the expense of wars of conquest therefor, the money sum in cases of purchase, the Indian wars and Indian service, the money and land subsidies to the Pacific railroads, the cost of all Territorial governments, all surveys within its borders, and indirectly certain parts of the cost of military occupation of the interior, and naval of the coast. Enormous as the aggregate of the above will be found, it is an investment well made by the country as a whole, as the great profits of an ever-increasing industry show, while the strategic importance of a continental expansion (land limited only at the north and south) within a single general jurisdiction can be measured only by the aggregated gains of industries developed, multiplied, and perfected, limited in time only by the life of the Government.

ORIGIN.

The Government of the United States became custodian or trustee of lands acquired for the nation, known as the public or national domain, first, from States (colonies prior to July 4, 1776), ceded under the Confederation and under the Constitution, in pursuance of a resolution of the Confederation passed Tuesday, October 10, 1780, providing for the reception and care of such unappropriated lands as might be ceded by States to the United States, and for the disposition of the same for the common benefit of the United States.

The first cession appears to have been made by New York, March 1, 1781.

ORGANIZATION.

The cessions of the several States were organized from time to time into geographical divisions by the laws creating them, and the lands were ordered to be surveyed, including lands to which the Indian title had been, or would be, extinguished. By ordinance of May 20, 1785, it was determined that a surveyor from each State should be appointed by Congress, or a committee of the States, who should faithfully discharge his duty under oath before the Geographer of the United States, which latter official was authorized and directed to carry out the subdivision of the lands preparatory to sale. Thus the first officer in charge of the survey of the public lands was called the "Geographer of the United States." Under the act of May 18, 1796, his title was changed to that of the Surveyor-General of the Northwest Territory.

Capt. Jared Mansfield, U. S. Army, filled this office from 1803 to 1813. Under him many and important changes and improvements were made in the surveying system which had been adopted in 1785.*

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* (See The Public Domain, 1880, p. 170.) These changes and improvements were the introduction of greater accuracy, and the determination of the principal lines by astronomical observations, as would appear from the following, although the published reports of the General Land Office do not give the detailed results. In a private letter from President Jefferson, of May 21, 1803, to Captain Mansfield, offering him the position of Surveyor-General (copy furnished by Paymaster C. D. Mansfield, U. S. Navy, grandson of Col. Jared Mansfield), after pointing out the defects then existing, he says: "We have been wanting also * * * accurate determinations by astronomical observations of several points and lines in our geography very interesting to us." He suggests for the Mississippi a compass-and-chain survey "corrected at proper intervals by celestial observations." Mr. A. S. Dudley, of Marion, Ohio (husband of a granddaughter of Colonel Mansfield), states that Colonel Mansfield accepted the office on the condition that proper astronomical instruments be furnished him for fixing points of latitude and longitude and locating meridian lines astronomically. President Jefferson ordered the proper instruments (at a cost of $1,054) from London. These instruments reached Colonel Mansfield at Cincinnati, Ohio, and were used in making many astronomical observations ordered by the Government. They are now on deposit in the Department of Philosophy at West Point. Prof. George

On May 7, 1822, the first surveying district was created, namely, the State of Ohio, with an officer called the surveyor-general in charge, since which time various States and Territories, either singly or two or more, or any of them, have been joined together for such purpose by law, and in charge of a surveyor-general with assistants.

The surveys have been made under the contract system, usually non-competitive, the surveyor-general selecting the deputy, Congress fixing the compensation.

These surveying districts are closed by act of Congress when all the public lands are surveyed and certain archives therein transferred to the State in which the lands lie.

ADMINISTRATION.

The administration of the public lands has been under the Treasury and Interior Departments.

Commencing May 20, 1785, under the Board of Treasury (three commissioners), the then Treasury Department made sales of public lands and gave certificates.

The General Land Office was created April 25, 1812. Upon the creation of the Department of the Interior, March 3, 1849, the General Land Office became and continues to be one of its bureaus.

FUNCTIONS.

The functions of the General Land Office cover the entire ground, commencing with the acceptance of public lands from certain States and further acquisition, and are based on ordinances and laws for disposing of the same, commencing in 1785, the general and permanent laws governing which were codified in 1880 and published by the Interior Department

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W. Davies, in his Surveying (ed. of 1841), states regarding the public land surveys, p. 4: "The method was originated by Col. Jared Mansfield, whose great acquirements in science introduced him to the notice of President Jefferson, by whom he was appointed Surveyor-General," and on p. 127, "The principal meridians and the principal east and west lines have been established by astronomical observation." Latitude and longitude checks upon the position of the principal lines of survey appear to have fallen into desuetude, and more than eighty-five years later the General Land Office is found prosecuting its subdivisions, substantially unaided by these geographic connections and checks, demanded alike by the scientific progress of the world and the requirements of a reasonable accuracy. One trusts that prior to the subdivision of Alaskan lands the system there established shall be based upon a skeleton or net-work of cardinal points geographically connected and determined with the highest order of accuracy. Accounts of the early surveys of the public lands may be found in Niles' Register.

While the actual surveys are but a small part of the duties devolving on this office, yet the system and method by which the subdivisions are determined has principally to do with the simplicity and security with which the settler gets his title.

SYSTEM, METHODS, ETC.

What is known as the "rectangular system" of surveys was first reported by a committee of Congress May 7, 1784. It provided that the public lands should be "divided into hundreds, of 10 geographical miles square, by lines to be run and marked due north and south, and others crossing these at right angles."

As amended and passed May 20, 1785, it provided that the lands should be divided "into townships of 6 miles square, by lines running due north and south, and others crossing these at right angles, as near as may be," etc.

The laws regarding surveys of the public lands may be found in U. S. Land Laws, General and Permanent, 1880, p. 20, sec. 99 *et seq.*, Chap. III.*

The law does not require the determination of the latitude and longitude of the base-lines and principal meridians, and, so far as is known, no proposition was ever made to introduce altitude determinations or systematic topography into these surveys, the latter as practiced being purely planimetric and incidental to the subdivision proper.

COST.

The surveys of the General Land Office had cost approximately to June 30, 1879, including surveys of boundary lines and Indian reservations, $23,672,606 (see p. 475, House Ex. Doc. 270, Forty-eighth Congress, second session).† The survey appropriations since to June 30, 1888, have reached a total of $25,795,195.09.

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* A statement as to the surveys of the public lands will be found in Chap. VII, p. 178, The Public Domain, 1880.

† The acting commissioner of the General Land Office, in letter of January 15, 1886, states that "the total area of the public lands surveyed to and including June 30, 1885, is 909,945,198 acres, and the estimated cost, including the expenses of maintaining the offices of the surveyor-general, was $31,500,409.74, or an average of 3½ cents per acre."

THE RESULTS.

The survey results have been the subdivision into legalized tracts of 971,174,878 acres and the running of, approximately, 5,372 miles of State and Territorial boundaries.*

This most important service, especially on account of the simplicity and utility of the system of subdivision, has been of incalculable benefit in the development of the far western interior, and while the actual execution of the lineal survey work has not been of a high grade of accuracy because properly skilled surveyors have not been employed, still it has given the practical information upon which the Government has been able to base a patent, parting with its title, and by means of which the settler has been able speedily to enter upon and occupy the land.

In a newly settled and rapidly growing country it is impossible practically to carry out an elaborate system of subdivision with the greatest practical scientific accuracy. The pressing calls will not permit, and as was found in the colony of Victoria, a geodetic system (see p. 181, House Ex. Doc. 270, Forty-eighth Congress, second session) was introduced and proved a failure, while on the other hand the Dominion of Canada, after examination and comparison of all known methods of land parceling, has based its subdivisions upon the system originally introduced in the United States and carried out very much in the same manner as was intended by Captain Mansfield that the surveys of the United States should have been prosecuted, who may be termed the founder of the rectangular system, geographically disposed and checked.

It may be remarked that the absence of geographical points and imperishable monuments established *pari passu* on the main and subsidiary lines of the public land surveys will be the source of the most fruitful litigation in the future, when increasing population, production, and consequent value to land demand more accurate bounding lines to properties. Having been brought in connection with the practical work of subdivision surveys in the field in no less than fifteen Western States and Territories, I may be pardoned for stating certain things which have been brought to my notice which could obviously be benefited. Among them are—

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* Of the 971,174,878 acres reported by the Land Office as having been subdivided June 30, 1886, 724,629,431 acres lie west of the Mississippi, while of the 844,229,269 acres then remaining unsurveyed all except 7,856,857 acres (Florida) belong to the same territory, including, however, 369,529,600 acres (estimated) for Alaska, where these surveys have not yet been commenced. It appears that the present law requires the establishment of no latitudes, longitudes, or altitudes in connection with these surveys, neither has it been the custom to conduct systematic topography, the latter being simply planimetric, without a geographic basis; hence the results of the Land Office surveys, so far as their uses in the compilation of general topographic and geographic maps, are but preliminary on account of these deficiencies, the data transferred being only such minor details as can be adjusted to the known geographic co-ordinates. For preliminary field and subsequent office plats they have, however, furnished valuable information.

(1) The want of well-determined astronomic or geodetic check-points in the establishment of the main meridian and standard lines, for their grouping geographically, and for controlling errors.

(2) The necessity for a more uniform system of marking all main lines and every corner of each tract in the scheme of subdivision.

(3) The establishing of base-lines each on a true meridian centrally within each mineral district, and the establishing of more permanent initial monuments; these latter should be of iron, and deeply planted.

(4) The connection of all the exterior of each surveying district with fixed points or boundaries, or those geographically fixed, so that the whole shall intercommunicate and check, and not prove finally a blotch upon the great and perfect map of the region as they now do to a great extent, but become a permanent contribution to it.

While it is extremely important that these changes should be applied in the completion of the surveys in each existing district, the utility is paramount in the case of Alaska, over which the land laws soon must reach. It is sincerely to be hoped that most radical reforms will be introduced into the surveying service before the large area of Alaska is entered.

A survey of this character must always be lineal, and it would be most unfortunate should the attempt be made to introduce a system of altitudes, or topographic details, other than planimetric.

The present system of subdivision should be left intact until everything except the absolutely desert lands remain unsurveyed and unoccupied, when the necessity for their final disposition must force upon the attention of the Government the preparation of a practical land classification, by means of which the central office at Washington may be informed of the exact character of the tracts left undisposed of, which would be worth to the Government, the settlers, and the nation one hundred times its cost.

This classification should take into account each and every kind of land known to the law, including the railroad and other grants, with reservations, Indian, military, or otherwise, and should show the class of the desert land, that is, whether permanently sterile or arid for want of water, or worthless from any other cause.

NOTE.—It is estimated, assuming table on page 531, Public Domain, edition 1883, that there are about 200,000,000 acres of desert lands, other than those on reservations, that can not be irrigated. The above table gives for June 30, 1883, the estimated character, quantity, and value of the then remaining public domain.*

MAP.

A sketch map has been compiled and is here introduced, showing the stage of progress of the public land surveys of the Interior Department, and the military, topographic, and geographic surveys of the War Department on June 30, 1879. Since this date the total area subdivided up to June 30, 1886, has reached 971,174,878 acres, and the area remaining unsubdivided is 844,329,269 acres.

As a result of the persistent solicitation of certain geologists and others, upon the organization of the Geological Survey, funds for War Department works have not been available, and only such topographic details have since been gathered in these regions as are desired by the geologist as the groundwork for the geological data, which is superimposed in colors upon his topographic map as a base.

Surveys needed for military and economic purposes must wait either until individuals who control in the name of science are broad enough to comprehend the whole situation, or the Departments needing data succeed *ab initio* in securing Government action each in favor of itself.

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* From the fourteen States and Territories, on page 31, Progress Report, 1872, within which the survey has operated, there had been disposed of up to June 30, 1886, the sum of 363,639,466 acres, which, assuming 333,957,198.58 acres of railroad and other grants, reservations, etc., to be subtracted from the total amount of 977,043,210 acres, shows an apparent acreage of 279,446,536.48 then remaining undisposed of in the surveyed area, which amount is to be increased by the patents issued in favor of these grants from 1872 to 1886, the reservation areas remaining about the same. Applying arbitrarily the percentages actually found for about 175,000 square miles surveyed, there would result, approximately, 20,000,000 acres arable, 188,000,000 acres grazing, 105,000,000 acres timber, and 66,000,000 acres arid or barren. The lands disposed of during the interval were principally arable and timber, hence the grazing and arid areas remaining would be greater. However, irrigation and reclamation will bring, ultimately, portions of the natural grazing and timber areas under the head of arable.

The map shows, independent of the township lines of the actual land survey subdivisions, the areas of the Fortieth Parallel Geological Exploration and the Geographical Surveys west of the 100th Meridian, by lines the routes of eighty War Department topographic expeditions, the areas of Indian and military reservations, and the Indian Territory; also the reservations of the Yellowstone Park, Yosemite, and Mariposa Trees, confirmed and unconfirmed land grants, and grants for rail and common roads west of the Mississippi.

It shows the work of the geographic surveys to have been mostly in advance of the land surveys, and largely in areas untouched by land-survey lines, principal or minor. In areas common to the operation of both the geographical and land surveys, the latter were supplemented by the vertical element of topography and further details, all being merged into and governed by a trigonometric net of points geographically established.*

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* The long experience that served to familiarize one with the later practices of the public land surveys and the interest engendered are the justification for the following suggestions:

(1) The lands should be subjected to a field classification in advance of subdivision, according to kinds recognized by law, and such other divisions, as irrigable, grazing, etc., as experience shall dictate.

(2) A geodetic net (astronomically checked) of points should be spread, as circumstances permit, over the whole system, and uniform monuments should mark all the larger and lesser points, even to the quarter-sections.

(3) The present method of subdivision, checked as above, should remain intact, but the law should grant irrigable and pasturage lands under new conditions as to amount, methods of securing, and eligibility; and subdivisions, even to 10-acre tracts, if necessary, can serve to segregate the several classes of land recognized by law.

(4) A new mining law should give title to a specified amount of surface, and to all that lies thereunder, and while the form of the claims may be made adaptable, *i. e.*, rectangular or square, yet these subdivisions should be connected and harmonized with those of the general system.

(5) As rapidly as possible the final status and limits of all railroad and other grants, together with all Indian, military, and other reservations, should be made upon the ground, and a geographical distinction be made for their limits and boundaries. From the field data soon should grow a map whereupon preliminary office traces of every quarter-section, within each and every quarter-section, could be computed and delineated in advance.

(6) Too much attention can not be given to the complex question of how best to dispose of the remaining public lands. It may be remarked that in 1858 the Geodetic Survey of Victoria attempted to apply a trigonometric check net to rapidly extending disconnected selections but failed, probably because the scientific work demanded precedence of the linear subdivisions. The two classes of work should be distinctly separate, co-operating in effect, but governed by appropriate instructions for each.

The method of survey of the public lands of Canada are, as regards subdivision into tracts, based on the rectilinear plan adopted in the United States, but in practice check, astronomic, and trigonometric points are a feature, and topography to some extent, the latter by the selected and qualified Dominion topographical surveyors.

APPENDIX E.

CONSIDERATIONS UPON NATIONAL GOVERNMENT LAND AND MARINE SURVEYS.

(With map.)

From the date of my assignment to duty in the office of the Chief of Engineers, in 1871, for the purpose of perfecting plans for explorations and surveys in the interior, and subsequent assignment to the charge of geographical surveys, all information possible, consistent with my arduous duties, was necessarily gathered bearing on the principles, practices, and results of Government surveys.

This information, as obtained, was held within the archives of the Survey Office, and my visit to the International Geographical Congress at Venice proved to be the opportunity for supplementing it by personal observation and otherwise.

Out of this examination grew that part of the report on the Venice Geographic Congress (House Ex. Doc. No. 270, Forty-eighth Congress, second session) which contains a large amount of detailed information, some of which, where appropriate, has been found germane to this appendix, proposed and authorized at the date of the law for the series of quarto reports.

The purposes and objects of the principal general surveys of the several great Governments that in consequence of the importance, magnitude, and variety of the interests involved assume an extent and demand a minuteness and accuracy seldom, if ever, required by single communities or individuals, are to aid (1) defense, (2) navigation, (3) commerce, (4) other industries, and incidentally (5) science.

These surveys are divisible into three classes:

(1) Topographic.
(2) Hydrographic or marine.
(3) Cadastral or revenue.

The first become geographic surveys when sufficiently extended and fundamentally based upon initial astronomic points with a trigonometric extension and when accompanied also by examinations in the physical geography branches of mineralogy, geology, and natural history.

The name defines the second.

The third,* applicable to revenue purposes in older and thickly settled countries and to land subdivisions for settlement in newer countries, are simply planimetric. The surveys necessary for great engineering operations are naturally the outgrowth of the constructions demanded, being a proper function alone of the engineer in charge.

There are derived, especially from the first two, maps of given areas, which possess when produced by Governments, as compared with those made by private means, a truthfulness and accuracy which either are or ought to be above suspicion, resulting from a *general* and not a *special* survey.

All of these works in Europe are based upon and held subsidiary to large and permanent governmental wants, or as an aid to specified industries.

It never having been the practice of the General Government to levy a tax upon land, there is no requirement on its part for a cadastral survey; the latter, whenever undertaken, must be subject to the State or municipal authority, except for the 10 miles square of the District of Columbia, the supreme jurisdiction over which rests with Congress.

Were such a survey to be made it should rest upon a rigid trigonometric basis with added levels of precision, the resulting map to be in contours.

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* Cadastral, from the French *cadastre*, is defined as "a plan from which the area of land may be computed and from which its revenue may be valued."

By the assistance of these maps the system of surface and underground improvements and repairs could be estimated for and constructed with greater celerity and certainty. A survey is not by nature integral and enjoys its proper functions only as an aid or auxiliary, as for instance, to works of construction where an instrumental analysis is required, or, as in cases of fortifications, internal improvements, or assisting navigation by pointing out the most available routes and the danger of others, or for the simple division of land.[*]

Hence the nature of the survey, its organization, methods, and results, should be held subordinate to the industry to be assisted or the specified want, as, for instance, the proper function of the hydrographic survey of the coast is as an aid to "navigation," that of the northern lakes of the United States was an aid to "commerce," while the public land survey is for the speedy and simple marking of legalized tracts to facilitate transfer of title; that of the river and harbor examinations is as an aid to the projects of permanent improvement that can alone be consummated by engineering skill. In all cases the survey is but secondary, acting as a technical guide in the important operations cited.

In the main, then, the extent of the survey should be governed by the requirements, through the Executive Departments of the several works, as of engineering constructions, internal improvements, promotion of commerce, navigation, etc., while the quality of the results should in every instance be dependent upon the amount of exactness and detail necessary, but will in a great measure, however, be governed by the skill of the individuals secured for the task.

In the main, the Government should be actuated by the requirements of the Departments in which is lodged the jurisdiction over operations that demand surveys for their intelligent prosecution. No organization for survey duties alone, fixed by law as to numbers, is needed, and all present and future surveys could be made by the permanent and trained officers of the military and naval services associated with selected civilians. Although the advantages of concentrating all survey duties in the hands of one organization are many, yet they are exceeded in importance by the certain danger of this one organization becoming in time further and further removed from the practical wants of the Government itself, and, finally, superior to the purposes for which it was created.

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[*] The land surveys require a linear survey, accurate within certain limits, of legal-sized tracts, the corners of which should be marked with durable monuments. As these surveys cover large areas and are also widely separated in the several political divisions, the main and subsidiary meridians and parallel lines to which the subdivisions are referred should be frequently checked in geographical position. This has mainly been omitted thus far in the survey of the General Land Office, to the manifest detriment of the interests both of the Government and people; and no uniformity or permanence having been secured in the marking of boundaries, it is often difficult to re-establish legal corners with certainty when the stakes, stones, or other marks have once been removed,

Workers in the various scientific branches required in these surveys should be made to bend their endeavors to immediate practical ends, which, if not done, tends to foster a patronage of science by the Government, than which nothing could be less conducive to its true progress or more inimical to the interests of the Government in this regard. The works inaugurated should therefore be classified and administered according to their nature and the objects sought, and not by the means and men put in requisition for their execution.

The grand general topographic survey, upon which the resulting maps depend, is principally made up of three parts, viz, the triangulation, the topography, and the cartography. The main or primary triangulation rests on bases measured with the highest attainable accuracy, the origin of the geographical co-ordinates of which depend on initial astronomical determinations of the first or highest order of value; from these datum points as loci a net-work of triangles is developed, with sides varying from 10 to 100 miles in length. The latitude and longitude, at least of one vertex, and the azimuth of one side of each triangle, is then determined with the greatest care and precision.

The primary triangulation forms the frame-work of a lesser or secondary triangulation, from which the area is always subdivided by a tertiary triangulation. In extreme cases a further triangulation of the fourth and fifth order has been made.

The points thus determined become the initial stations of the topographer.

The original field-notes* or plane-table sheets of the topographer, supervised and inspected by competent officers in the field, go to the hands of the cartographer, by whom, under rigorous official supervision and inspection, they are reproduced on the same or a reduced scale for publication.

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* In Europe, except for England and France, the topographic field-notes have, as a rule, been laid down on the plane-table.

These mathematically based topographic surveys, extended as they are to embrace large areas, where surface curvature is taken into account, become geographical surveys of the highest order of perfection yet reached, forming when properly done the mathematical frame-work for all geography. The cadastral survey usually, depending on a planimetric base and linear measurements, while extended also to embrace large areas, employs only a simple net-work of lines bounding properties.

It will be seen that the first and most useful function of geodesy is as the triangulation factor of a topographic survey, then when a requisite preliminary knowledge is thus had, to extend its purpose as an adjunct to the classes of observations necessary for the most accurate possible measurements of the figure of the earth, while it should be remarked that the work of detailed geologic examinations can not properly begin until the topographic map is prepared for use as an index or graphic field note-book.

The topographic survey lies at the foundation of all that constitutes finally an exact knowledge of physical geography, and no such survey is complete until all the natural and artificial features are mathematically measured, recorded, and delineated, the configuration being shown by equidistant rigidly accurate contours at intervals suited to all requirements. These requirements are properly dictated by the results demanded, as well as by time and cost, since the latter, for instance, were the contours carried to the greatest precision demanded by military engineers in the studies for construction of permanent fortifications, and made applicable to the entire area of any given country, might readily be made to exceed the value of all the land and other wealth found therein.

Reproduction is by hand or mechanical engraving on stone, zinc, or copper. Hand engraving, especially on copper, is a long and costly process (reaching as high as $45 per square inch for hill work), and has been replaced by photographic transfer—*i. e.*, photolithography when the receiving and printing surface is stone, photo-zincography when zinc is used, and heliogravure for copper. The latter has been brought to a high state of perfection in Austria, and is used also for reproducing military topographic maps in Italy and Russia. Various means, chemical and otherwise, are now being attempted, with more or less success, for obtaining, with the greatest directness and clearness, transfers of specially skillfully delineated originals, from surfaces of zinc and copper. Chromo-lithographed maps are much employed in Continental Europe, as, for example, the new military map of France, 1 : 50,000, also French war department maps of scales 1 : 800,000, 1 : 500,000, 1 : 400,000, 1 : 200,000, and 1 : 100,000; military maps of Holland, 1 : 50,000 and 1 : 25,000 (Eckstein process); map of Italy, 1 : 100,000; the new map of Spain, 1 : 50,000, etc.

Without exception, in all Europe, and wherever topographic surveys have been systematically developed, the geologist avails himself of the topographic map as a base work, and preliminary to his investigations in the field, and upon which to delineate and publish in colors his theoretical abstractions as to the several geological formations and their lines of demarkation, according to the classification and nomenclature in vogue in the several countries, but in no case known to me has the geologist had or exercised jurisdiction or control over the more important and fundamental operations upon which the trigonometric and topographic survey and its results are based, nor even in connection with the mathematical construction of the detailed map, the functions of which, as will be seen, are dominated by broad and general requirements pertaining to one of the highest duties of government, the country's defense. When once the natural features, with all means of communication, are determined, this map can be developed in economic succession to meet all industrial wants, national, state, municipal, and individual, and it can not be confined to the comparatively narrow requirements of special branches of science.

These topographic maps are found indispensable, not alone to the war departments of the several Governments for all general as well as special military operations (strategic and otherwise), but of primal importance to other departments as well, especially those organized to promote the industries of agriculture, commerce, and mining; to those engaged in public works of interior improvements relating to means of communication, flow of waters, establishment and perpetuation of harbors (in their conception and study), thereby, as in other like cases, saving long and expensive researches; in the decision of claims; in selecting areas for cultivation; also in works of irrigation; arterial drainage of marsh and swamp lands, as well as in prevention of inundation, and also as aids to artesian boring and in the management of forests; they are useful also in illustrating the economic classification of the soil; for the recording of general geological investigations, including the several formations and the distribution of extinct as well as living fauna and flora; as an aid in the study of meteorological phenomena and in scientific researches generally; as preliminaries to the projection of railways, canals, and other lines of communication; to the hydrographic surveyor in his field of operations; in the establishment and marking of post routes, completed railroads, canals, and telegraph lines, as well as reservations, administrative and other boundaries; also for the enlightenment of justice; the elucidation of questions of history, ancient geography, ethnology, or archæology in international treaties, cessions of territory, and rectifications of frontiers. In Europe, especially, the map, prepared in advance, or *pari passu* as a preliminary to any of the above undertakings, is considered almost a *sine qua non*. In addition to governmental uses, those for municipal and educational purposes, and by the people generally, are too numerous for mention here.

The principal Government maps now in use can be classified under the heads of (1) topographic, (2) economic, (3) cadastral.

Since the vertical element of the topographic survey has reached a greater degree of refinement, the map has frequently been designated as orographic, chorographic, or hypsometric. The economic maps are severally known as those for land classification, agricultural statistics, routes, post routes, drainage, forestry, sanitary purposes, railways, telegraphs, interior communications and navigation, river and harbor improvements, national roads, ports, for recording geologic, mineralogic, and meteorologic results, etc.

The above (except engineering maps) are all based upon the original or mother topographic map, with or without the orography, and varying in amount of detail.

There are also special engineering, magnetic, natural history, ethnographic, archæologic, historic, boundary and outline or planimetric maps (generalized), the latter usually on a small scale.

By far the most important or paramount use to which the topographic map has been applied is naturally that for military purposes (in fact in this connection the terms military and topographic are synonymous), since a military establishment, with its varied functions, is necessary to every Government for the full and final protection of its citizens, and the defense of its soil with the structures and improvements thereon, while the first necessity of the strategist is a thorough knowledge of the physical conformation, the obstacles and resources of a country in which operations are to be conducted, and no military commander has ever in advance thoroughly and successfully planned a campaign, or properly carried on the operations thereupon consequent, or conducted armies in advance or retreat, protected lines of communication and the forwarding of supplies, or has grasped the situation as a whole in the numerous details required by the advanced state of military science and art, except by a thorough and free use of a full supply of accurate topographic maps, upon which are delineated all the natural and economic or artificial features, and of the means of transit over the territory to be protected or the region embraced within the scope of the military operations.*

Other than the topographic map of every scale, used by the war service of Governments, are special maps for military uses, as of passes and positions, camps, garrisons or posts, maneuver grounds, for tactics, war, and fortification studies, of fortified, halting, and camping places, and itineraries, prepared and published generally on scales from 1:500 to 1:12,500. Most of the above are held alone for confidential Government uses.

All of these without exception, upon scales (large and small) dependent upon either a study of actual theaters of war, or approaches thereto, or intercommunication, are a true requirement of the strategist and commander, and thus very properly through the centuries topography has grown up a permanent unvarying essential of the military profession, than whom none other is ever to have the same need for the knowledge thus made available.

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* The great and increasing range and accuracy of artillery and small-arms are constantly rendering a more intimate knowledge of the contour and accidents of constantly greater importance.

In Europe the possession of good maps has now become of recognized importance to the citizen, be he a professional, manufacturer, agriculturist, or merchant, as well as to the soldier or Government, while their use to all classes of the public increases with each decade.

If the detail is carried to that required for revenue purposes (as for instance to the scale of 1 : 2,500 employed in England), the whole based on the trigonometric points needed for the topographic survey, the added uses of the map are for purposes of registration, valuation, and transfer of land.

In addition to the general topographic and cadastral survey special surveys are required for the sites of fortifications and vicinities, defensive field-works, and other Government constructions, upon which to base all works for drainage and improvements in cities and large towns (the latter cared for by the general governments in Europe); and, especially in the United States and the colonies of Great Britain, the land-parceling surveys, as an aid in securing and perfecting title.

There have been noted as employed on the topographic or base-work series of maps of Europe names, conventional signs, and abbreviations to the number approximately of 1,148, which may be divided as follows: (1) Those representing natural features, or (2) pertaining to means of communication, (3) agriculture, (4) commerce, (5) manufactures, (6) mining, (7) miscellaneous, (8) special military, (9) special technical, and (10) boundaries. Colors have been employed for representing more distinctly a number of objects from each of the above classes.

One of the results of modern civilization in its quest after habitable lands for their advantages to the multiple wants of man will naturally be to gradually subject the temperate regions, at least, to the analysis of a minute topographic survey, the value of such data having already become so well fixed in the polity of the older civilized nations.

The following lists show the distribution of areas "undergoing" and "not undergoing" systematic topographic surveys:

Areas undergoing systematic instrumental, mathematical, topographic surveys (based on computed triangulation).

Continental divisions.	Area undergoing survey.	Population.	Scale of topographic maps.	Remarks.
1. Europe	2,412,417	305,804,737	1:10,560 to 1:126,000	States of Great Britain and Ireland (United Kingdom), France, Spain, Portugal, Belgium, Holland, Denmark, Switzerland, Germany, Italy, Austria, Norway, Sweden, Russia (inclusive of Poland, Finland, and Roumania).
2. Asia	2,867,906	271,000,000	1:[illegible] and 1:100,000	India and Java.
3. Africa	242,485	2,867,626	1:50,000	Algeria (a department of France).
Total	6,022,808	578,[illegible]		

NOTE.—The "population" is taken from Behm and Wagner's "Die Bevölkerung der Erde, VI," 1880.

Areas not undergoing systematic instrumental, mathematical, topographic surveys.

Continental divisions.	Area not undergoing survey.	Population.	Remarks.
1. Europe	254,745	10,801,203	Bosnia, Herzegovina, Luxembourg, Servia, Montenegro, Bulgaria, Turkey, and Greece.
2. Asia	14,841,300	563,394,400	All except India and Java.
3. Africa	11,304,551	202,811,274	All except Algeria.
4. America	14,922,074	86,000,000	All except United States. (The latter proposed only.)
5. Oceanica	3,457,034	4,031,000	The entire area.
6. Polar regions	1,745,226	82,000	Do.
7. United States	3,025,600	50,155,783	Proposed only. Special surveys in progress.
Total	46,650,110	909,232,220	

The foregoing shows that a little over 6,000,000 square miles have been so surveyed, or are undergoing such survey, or about one-ninth of the land portion of the globe, while the balance, or about eight-ninths, inhabited by over 900,000,000 of people, is comparatively poorly known, or, in part, a *terra incognita* from a true topographic standpoint.

The only principal works of Standard Interior Topographic Surveys for the whole world (all directed by army officers) are nineteen, as follows: (1) United Kingdom, (2) Germany (Prussia), (3) Saxony, (4) Bavaria, (5) Wurtemberg, (6) Baden, (7) Austria-Hungary, (8) France, including Algeria, (9) Switzerland, (10) Holland,* (11) Spain, (12) Italy, (13)

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* There is also a government topographic office at Batavia, Java (Dutch East Indies).

Sweden, (14) Russia, (15) Belgium, (16) Denmark, (17) Norway, (18) Portugal, (19) India.

Hydrographic surveys of domestic and foreign coasts are being carried on alone by the marine ministries or navy departments of the following countries: (1) Great Britain, (2) France, (3) Germany, (4) Italy, (5) Austria, (6) Japan, (7) Sweden, (8) Holland, (9) Chili, (10) British India, (11) Portugal, (12) Denmark, (13) Spain, (14) Russia, (15) Belgium,* (16) Norway, (17) Java (East Indies).

There are special organizations for geological examinations and investigations and allied research (systematic work and reconnaissance) in the following states; (1) Alsace-Lorraine, (2) Austria, (3) Bavaria, (4) Belgium, (5) Finland, (6) France, (7) United Kingdom, (8) Hungary, (9) Hesse-Darmstadt, (10) Italy, (11) Luxembourg, (12) Norway, (13) Prussia, (14) Roumania, (15) Russia, (16) Saxony, (17) Spain, (18) Sweden, (19) Switzerland, (20) Algeria, (21) Cape Colony, (22) India, (23) The East India Netherlands, (24) Japan, (25) New South Wales, (26) New Zealand, (27) Queensland, (28) Victoria, (29) Canada, (30) Greenland, (31) United States, (32) South Australia, (33) West Australia, (34) Servia, (35) Wurtemburg; all within the jurisdiction of various civil departments of the governments, such as the interior, public works, commerce, industry, public instruction, etc.

These examinations and investigations usually embrace the branches of minerology and paleontology, with chemical and microscopic analyses, and are either general in their character, locating and defining the rock and other formations, by means of surface examinations and those made in mines, or by boring and cross-sections, using the togographic map as a basis upon which to illustrate the former, with colored sections added, and in some cases investigating the dynamic forces, past or present, in relation to the development and present condition of the earth's crust, or economic, as in examining for the causes surrounding the presence of the valuable mineral constituents found in rocks and soils, and in analyzing soils and pointing out their relative values for specified purposes.

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*This work in Belgium (having no naval department) is found under civil administration; in Portugal, supervised and directed by naval officers, it is grouped under a bureau of geodetic works.

The resultant geologic map, one of the most important practical objects and results of such an examination, while exceedingly valuable for the student of geology and the miner, is less useful to the world at large, and the governments more especially, than the purely topographic map upon which the colors are superposed, the latter and the special geologic signs tending somewhat to confuse the topographic detail proper.

In other words, the topographic or mother map of a country is the one that all the world may use, while the geologic edition of the same is limited in its utility to a by no means large class of specialists, and to specified industrial wants.

Government geologic investigations seem first to have been begun in France in 1825, followed by England in 1832, Belgium in 1836, Russia in 1840, Austria and Spain in 1849, India in 1851, Holland in 1852, Portugal in 1857, Sweden and Norway in 1858, Switzerland in 1859, Prussia in 1862, and Italy in 1868. G. W. Featherstonaugh, an English geologist, was the first to conduct geologic work for the United States in 1834 and 1835, making reports to Colonel Abert, chief of the Corps of Topographical Engineers in 1835 and 1836. Similar examinations specifically authorized continued until 1852, when they were stopped by law, after which geologists accompanied exploring parties, and geologic exploration itself was revived in 1867, and the present Geological Survey afterward created by statute in 1879.

The work of these organizations is under the control of commissions in Alsace-Lorraine, Belgium, France, Hesse-Darmstadt, Italy, Luxembourg, Russia, Switzerland, Wurtemberg, which commissions are composed of the director of the work, in certain cases of officers of the topographic bureau, professors of geology, mining engineers, practical geologists, and others.

They are directly under the administration of mines in Austria, Bavaria, Finland, France, Italy, Prussia, Russia, Spain, Algeria, Java, New South Wales, Queensland, and Victoria.

The operations are under the direction of the bureau of geodetic and topographic works in Portugal, and under the topographic bureau in Wurtemberg.

Elsewhere the chiefs or directors appear to report directly to the head of the departments severally known as of agriculture and mining, public works, letters, science, and fine arts, commerce, industry and agriculture, home and interior departments, imperial domain (Russia), finance (Saxony), revenue and agriculture (India), department of mines and water supply, etc.

It should be mentioned, however, that the several European Government departments above enumerated enjoy legal jurisdiction over the several industries specified, different from any of the grants of our own Constitution or legislative acts thereunder. Many European Governments, unlike the United States, either own or exercise a control over the mineral resources of the state, which in some cases has been the direct cause of the geologic examination.

The functions of the geologic works in the main may be stated to be the prosecution and execution of a geologic examination of a given region, at once useful to science and the economic interests of the country. This entails the production (usually by direct superposition of colors, or by compilation) and publication of general and special geologic maps, based on the topographic map (a separate function in all the older nations), also geologic profiles, sometimes with, as well as without, explanatory text.

Original topographic work, in areas selected by the geologist, has been carried on *pari passu* with the geological examination in certain newer countries where the topographic works have not been brought to a permanently organized state, but in none of the cases observed has the geologist undertaken the mathematical, instrumental, triangulation, or topographic work.

Monographs and geological and paleontological reports usually form a part of the duties of this office, as well as the collection and care of all documentary evidence requisite, bearing upon the work in hand and of objects of geologic and mineralogic interest, as rocks, fossils, etc.

These works, although yet young, are highly important and have been conducted with great activity and zeal, often in the face of numerous obstacles and with sometimes scanty funds, the latter elsewhere than in the United States.

The methods of geological examination appear to be more individual than following a formulated convention, the field observations being very simple, especially where the geologist is equipped in advance with a complete topographic map.

The cost per square mile it has been difficult to ascertain, if indeed it has ever been strictly computed for any given class of geologic work, for the reason that, independent of their unformulated condition inherent to their very nature, the scope of the investigation, for reasons theoretic or practical, may be varied and prolonged indefinitely.

Government topographic surveys will be referred to according to their "measure," "the men," and "the results."

THE MEASURE.

The general object or purpose for which a survey is to be made having been decided upon, the *measure* comprises, (1) the grade or class; (2) the Department controlling jurisdiction; (3) the plan with estimate of aggregate cost; (4) the subsequent annual projects with accompanying estimates; (5) the methods employed with regulations thereunder; (6) detailed field and office instructions; and (7) the limit as to time for the accomplishment of each class or kind of result pursuant to a definite plan, with estimates, approved in advance by proper authority.[*] The above are to be applied in each of the three great natural divisions of Government surveys, *i. e.*, (1) topographic (becoming geographic when accompanied by examinations in mineralogy, geology, and other branches of natural history); (2) hydrographic or marine; (3) cadastral or revenue, including all subdivisions of lands.

The term "topographic" (herein used in its most comprehensive sense) includes a variety of methods, all requiring that the principles of geodesy shall be observed in the measurements of bases and subsequent triangulation, with initial points astronomically determined as original points of departure. The surveys that properly come under this head are, (1) detailed topographic surveys looking to the "common defense" (interior, along international boundaries and coastwise, especially including all possible prospective theaters of war*); (2) of sites for fortifications; (3) of localities of river and harbor and other internal improvements that should include a network of lines, trigonometrically based and carefully measured, covering the area of all the navigable waters of the United States, establishing latitudes and longitudes with the requisite number of altitudes resulting from levels of precision, with meanders and cross-sections, and proper topographic and hydrographic details of all navigable coast and stream lines upon which to base a complete connected and permanent system of improvements (by a slight development of the belts of triangles thus required points may be established in aid of State surveys, at least one for each county in each State, and the trigonometric extension serve as the initial basis of the great general topographic survey of the country); (4) of the lengths of rail and common roads, canals, and water-courses over which the United States transports its troops, mails, material, and supplies; (5) topographic surveys in detail of the public domain west of the Mississippi for military and other purposes, and incidentally the agricultural classification of the public lands not yet subdivided, and to include where required additional meanders of new routes, all finally to be availed of for, and merged into, a great general topographic survey of the whole country. It is needless to add that no such important works can be successfully prosecuted, with the highest attainable vigor and precision, except under a rigorous military administration.

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[*] Before a survey is authorized, a plan including its scope, scale, accuracy, area embraced, results intended, and limit of duration with estimated total cost should be submitted, passing both the administrative and legislative scrutiny before approval. In pursuance of the general plan, annual projects should be submitted and receive administrative action whereby the progress of the work as to time and cost can be readily compared with the original total estimate, which should not be exceeded unless after the express sanction of Congress in view of substantial reasons therefor. The methods to be employed and regulations to be followed, prepared by officials specially designated for this purpose, should be approved, issued as the guide and made imperative and mandatory.

Unless Congress should be guided by the annual estimates made pursuant to a general plan, wherein total cost largely controls the organization intrusted with the expenditures, it is likely to drift into the position of a permanent beneficiary requiring annual appropriations for the establishment independent of the amount of survey work actually performed.

The preamble to the Constitution makes it one of the primal purposes of the Government to "provide for the common defense," and carries with it the authority therefor, while a wise policy based on the axiom "in time of peace prepare for war" should actuate the Government to systematically engage in the construction of permanent works of defense, and adopt all aids, accessories, and auxiliaries thereto.

The hydrographic surveys are in aid of navigation, and incidentally facilitate and promote commerce. Surveys for the latter, however, are and ought to be made by the engineers, who subsequently construct the improvement. Most of the original general hydrographic work for our sea-coast has been accomplished.

The grade of the survey is to be largely determined by the accuracy and detail of the results required, and while the basis upon which the survey rests should be attained by the best means of measurement, the devices employed for securing the minuter portions of the data must vary within wide limits. Whatever the executive organization for the survey parties, the administration of the work should be intrusted to the Department having the most immediate, complete and permanent use for the results, thus securing the most vigilant supervision. In event of foreign war or domestic revolt, rebellion, or revolution, whether the invaders approach by sea or land, the original data upon which is based the special or general topographic map should be under the control of the War Department, which then becomes at once the most important branch of the Government, necessarily planning and directing the principal operations; and in case of approaches by sea the same applies with equal force to the Navy Department, as regards the hydrographic data of the coast and its approaches.

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* The following appears in a memoir of John Anderson and I. Roberdeau, military topographical engineers, as early as 1816: "The undersigned do not hesitate to recommend, without the apprehension of being mistaken, or of its being attributed to any other than public motives, the completion of a frontier military survey of the whole interior and exterior of the United States."

The nature of the requirements of the administrative departments appears in the following table:

No.	Name of Department.	Nature of survey.
1	State	International boundaries.
2	War	Detailed topographic surveys for the common defense (interior adjoining national boundaries and coastwise), culminating in a general topographic survey. Sites for fortifications. Location of river and harbor improvements, including an analytical survey of all national navigable waters. Revisionary surveys, where necessary, of the Great Lakes and their harbors. Military, geographical, and topographical survey of public domain west of Mississippi, including reconnaissances, meander of routes, military reservations, etc.
3	Treasury ...	None, except preliminary survey of sites for light-houses.
4	Justice	None.
5	Post-Office	None. The distances along mail routes should be determined by the great general topographic survey.
6	Navy	Hydrographic or marine survey of the entire sea-coast, with bays, harbors, etc., and approaches thereto International longitudes and incidental hydrographic surveys of foreign coasts.
7	Interior ...	Legal subdivision of the public lands. Lines of Indian reservations. Boundaries between States and Territories. Geological examination and classification of the mineral lands.

NOTE.—For the Department or Bureau of Agriculture no surveys are necessary.

THE MEN.

After the available number of selected and trained officers of the Government belonging to the military and naval services is exhausted, it is comparatively unimportant who shall be called upon to assist in making the Government surveys, and provided means are taken to select individuals whose professional attainments are of a high order, whose special training eminently fits them for the work. Numbers of competent men are regularly educated and trained at the Government expense at the Military and Naval Academies, from whom selections are and can be made, while those of the civil list have usually been educated at the scientific or technical schools of the country, or have had like elementary training in foreign lands.

The military and naval services represent all quarters of the Union, and enjoying practically a life tenure, are more likely to hold the interests of the Government equally if not more sacred than their own, and more aptly find that time for study and reflection so necessary to the development of great schemes of survey. The available number is, however, comparatively limited. Not a few competent civilians have been trained in the practical schools of the Coast and Lake Surveys and the later Geographical Surveys west of the Mississippi, while any deficiency can readily be filled by the graduates of the civil scientific schools of the country.

The organized personnel so far regularly employed by the Government in its mathematical surveys have been:

(1) The Corps of Engineers (and prior to the consolidation act of 1863, the Corps of Topographical Engineers) regularly and also by detail upon the topographic parts of the survey of the coast. (See Title 56, Rev. Stat.)

NOTE.—It appears to work admirably in Spain where authority exists to select trained officials, specially qualified, wherever found, provided their experience is adequate. Examinations in geology and other branches of natural history requires specialists selected for their well-known attainments.

(2) Officers by detail from the ordnance, artillery, cavalry, and infantry.

(3) Officers of the Navy as called upon and by detail upon the hydrographic parts of the survey of the coast.

(4) Astronomers and others of the Coast, Lake, and Geographical Survey.

(5) Surveyors-general and their deputies, who are to be "skillful surveyors," and contract surveyors of the Interior Department.

(6) Topographers of the Geological Survey engaged in the production of the topographic base map used by the geologist in his field examinations.

The number available for selection from the above sources, excepting, perhaps, the fifth, can readily be kept employed. The scope and intent of their duties should be, however, defined with the utmost precision by law.

As the surveys of the inland portions of the United States are practically as yet in their infancy, as compared with those of foreign nations, it is safe to expect that they will be extended over continuous intervals following systematic plans, and hence a personnel of skilled men will be required whose number will naturally increase and whose tenure should be made as permanent as practicable.

THE RESULTS.

The results of the land surveys are accomplished when the approved plats of the subdivisions reach the General Land Office and the patents in accordance therewith are issued. These surveys have alone a practical mission to fulfill, and are not, nor should they be, performed with any special pretense of great scientific accuracy. The geographical and topographical surveys, to the contrary, should be carried out on a connected scientific basis, with published results appearing in sketches, maps, and reports of the highest order of merit, emanating through the administrative department in control.

All the map data constitutes a substantial contribution to the great future general topographic map of the United States that it will take generations to complete, and the jurisdiction over which should be confined to a single branch of the Government, instead of being distributed as at present. The final maps and systematic reports, other than the annual reports of operations, should be published in departmental editions of 2,000 copies each, with such additional number as Congress may order in special instances.

Authority of law should be granted for the sale of the maps and reports at cost price, and the bureau organization supervising the surveys should be directed to contract with business establishments for their convenient sale. The same should apply to the published results of the hydrographic or marine surveys and the geological investigations. The hydrographic surveys should likewise present their final results in a series of systematically arranged coast charts upon a projection convenient for navigators, with the usual reports devoted to such scientific investigations into methods as long continued and reported experiments may develop. This is especially applicable to the geographical and topographical surveys. There would thus result three sets of scientific reports: (1) From the geographical and topographical survey, in relation to admeasurements upon land; (2) from the hydrographic survey, in reference to measurements in and off shore and upon the adjacent coasts and in the deep sea; and (3) the geological and mineralogical discussions resulting from the examination of the geological structure and mineral resources of the interior. In connection with all these operations there should be made as circumstances permit collections of paleontologic, zoölogic, botanic, and archæologic specimens, to be subsequently transferred to the National Museum for deposit, arrangement, examination, classification, and report.

The law should define the proper co-ordination and co-operation of and between the several Departments of the Government in the prosecution of their works of survey.

The great general survey of the country is both a practical and scientific measure, and belongs to the domain of exact science, and should be withdrawn entirely from the field of theoretical science, or it can never be carried to a successful conclusion. This view, while absolutely correct as regards the interests of the Government, is also in favor of the best and most permanent recognition of the true and earnest workers in the theoretical branches of science.

The following table indicates the future surveys that will be required by the Government of the United States:

Future surveys that will be required by the Government of the United States.

Character of survey.	Department that should control jurisdiction.	Locus of jurisdiction.	Bureau or other organization that may be employed.	Remarks.
Subdivision of public lands.....	Interior	Whole public domain.	General Land Office.	This work to be kept separate and distinct from all other Government surveys.
Sites for and approaches to fortifications.	War	Whole United States.	Corps of Engineers.	Preliminary to and in connection with the construction and use of permanent works of defense.
River and harbor examinations, to include geodetic connections and levels of precision, surveys of Mississippi River, etc.	War	Whole United States.	Corps of Engineers.	To result in a trigonometric connection and analytical hydrographic survey of all navigable waters of the United States and the establishment of levels of precision, and to aid in State surveys.
General geographic and topographic, resting on a trigonometric basis (west of Mississippi River), also interior adjoining national boundaries and coastwise and incidentally agricultural land classification and for irrigation, and finally to embrace the whole country (The Great General Topographic Survey).	War	Whole United States.	Corps of Engineers, assisted by other officers of the Army and civilians.	For detailed topographic surveys necessary to the "common defense" and those for the complete military topographic map of region west of Mississippi, and finally the entire United States and maps for the Geological Bureau. (Land classification to embrace areas in advance of subdivision surveys.)
Coast, hydrographic or marine..	Navy	Whole sea-coasts of United States and Alaska.	Coast Survey consolidated with the Hydrographic Office.	To complete hydrographic survey of Atlantic, Gulf, Pacific, and Alaskan coasts, with resurveys of prominent harbors, etc. Tidal and other hydrographic observations, including international longitudes, and incidentally hydrographic surveys of tidal and navigable waters of foreign coasts of nationalities not prosecuting marine surveys.

Future surveys that will be required by the Government of the United States—Continued.

Character of survey.	Department that should control jurisdiction.	Locus of jurisdiction.	Bureau or other organization that may be employed.	Remarks.
Geological examination and mineral land classification.	Interior.......	Whole United States.	Geological Director and assistants.	Geological examinations of the public lands and their mineralogical classification (special investigations concerning distribution and mode of occurrence of precious and economic minerals within the States), including general geological structure—maps to be based on those executed by the General Topographic Survey.
Miscellaneous, as (1) International Boundaries. (2) Military routes, meander and wagon roads; Military reservations; Routes for national railroads and canals; Cadastral survey of District of Columbia. (3) Isthmus surveys. (4) Boundaries between States and Territories, Indian reservations. (5) Sites for light-houses, etc.	State (1), War (2), Navy (3), Interior (4), and Treasury (5).	Wherever required throughout the United States.	Officers of the Corps of Engineers and other branches of the Army, naval officers, and specially selected civilians.	To be made as required by officers at headquarters military divisions and departments, and by detail of officers and surveyors to the department where jurisdiction is lodged.

The works of survey first and most needed in the United States are (1) military and naval; (2) economic; (3) engineering and other scientific. Under the first head are those of sites for and approaches to fortifications; strategic frontier, coastwise, and interior belts;* all communications (natural or artificial); to be followed as required by a general detailed topographic survey of the whole country on a rigid mathematical basis (see index map herewith) including general hypsometric work and precise levelings; also the completion especially of the hydrographic features of the survey of the Atlantic, Gulf, and Pacific coasts, including off-shore hydrography, tidal observations, and development of danger to ocean navigation, along navigating lands adjacent to these coasts, with revisionary surveys when and where necessary, completion of the general hydrographic reconnaissance of the Alaskan coast, to be followed when necessary by its systematic hydrographic survey after the best and most approved methods.

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* The strategic belts first to be selected with reference to possible foreign invasion would be strips of territory not less than 200 miles in width along the Atlantic, Gulf, and Pacific coasts and the Canadian frontier as far as the western end of Lake Superior. A like strip surveyed less in detail for the present should follow the forty-ninth parallel to the Pacific, as also the whole Mexican boundary. The entire Atlantic, Gulf, Pacific, Alaskan, and Lake coasts are comprised in this survey with all the tidal waters of the bays, rivers, and an ocean and lake off-shore belt reaching to deep water.

Looking to domestic rebellion or revolution, the natural lines of division are those between the north and south, or substantially the line shown on the sketch-map as dividing the northern from the southern tier of districts, and for the east and west the dividing line between the Atlantic and Mississippi Valley districts, and between the districts of the Plains and those of the Pacific composed principally of the divides or water-sheds of the Appalachian and Rocky Mountain regions. Belts of not less than 150 miles on either side of the above boundaries should be surveyed in an amount of detail governed in a measure by the conditions of settlement of the regions thus covered, but sufficient for maps of a considerable scale.

Under the second, are the analytical surveys of all national water-ways,* including completion of that in progress by the Mississippi River Commission to be developed hydrographically to embrace the whole basin with the detailed revisionary surveys of the Great Lakes and other navigable waters when and where necessary; the systematic, agricultural, and mineral classification of all improved and unimproved lands, with results geographically delineated upon the topographic maps as a base.

Under the third should be included all the special engineering surveys for projects and construction other than those for general works of internal improvement of water-ways, the special surveys needed for the graphic illustration of geology and mineralogy (the general illustration of the former appearing on the general topographic maps as a base), with such added data for paleontologic, zoologic, botanic, and archæologic illustrations as these and other special branches of science shall demand from time to time.

From a scientific standpoint should be added such practical researches and developments in astronomy, geodesy, lineal measurements, terrestrial magnetism, gravity determinations, refraction, and other atmospheric conditions, the Gulf Stream, Japan current, and deep-sea operations, as shall benefit the accuracy, comprehensiveness, and completeness and fullest utility of surveys which finally in their broadest sense are to aid in the common defense, navigation, commerce, the other industries, science, and statistics.

DISTRIBUTION INTO DISTRICTS.

In event of carrying on proper mathematically based inland geographic and topographic surveys with geodetic connections, such as referred to, it becomes convenient to divide the country into a number of districts.

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* This should be developed finally into a thorough hydrographic survey for the whole interior of the United States, as the groundwork of the utilization of the entire natural water supply for regions with a surplus as well as those suffering from a deficit.

The sketch chart of the United States herewith shows eight such divisions, with 210 rectangles, each representing 1° 40′ latitude and 2° 45′ longitude, described as follows: (1) Mountainous or Pacific district, north; (2) Mountainous or Pacific district, south; (3) District of the plains, north; (4) District of the plains, south; (5) Mississippi Valley district (north); (6) Mississippi Valley district, south; (7) Atlantic district, north; (8) Atlantic district, south. The most easterly of these districts are obtained by following approximately the water-shed between the Atlantic and the interior from, approximately, latitude 42° north to latitude 32° 20′ north. From the first point the line of division extends to the head of the Niagara River, and from the latter to a point on the Gulf of Mexico a little east of the mouth of the Ocilla River. Thus the two Atlantic districts are formed, the junction between them being marked by the Potomac River from its source to the sea. The Mississippi Valley districts are bounded on the west by the western boundaries of Louisiana, Arkansas, and Mississippi to Kansas City on the Missouri; thence along the river to Sioux City; thence following Big Sioux River to the southwest corner of Minnesota; thence via western boundary of this State to forty-ninth parallel. The most easterly point of the dividing line between the subdivisions north and south is where the thirty-ninth parallel intersects the Atlantic water shed; thence following that parallel westerly to the Ohio; thence along the Ohio to its mouth; thence following the Mississippi to St. Louis; thence to Kansas City via St. Louis, Kansas City and Northern Railroad.

The western limits of the plains districts begins at the mouth of the Pecos, and thence by its eastern water-shed to its junction with the Atchison, Topeka and Santa Fe Railroad near Las Vegas, N. Mex.; thence to Denver via the above and the Denver and Rio Grande Railroads; and thence to Cheyenne by the Colorado Central; thence northwardly to Fort Laramie; thence to intersection of South Fork of Big Cheyenne by the 104th meridian of longitude; thence in a northwesterly direction to forty-ninth parallel. The latitudinal dividing line is from Kansas City, Kans., to Pueblo, Colo., via Atchison, Topeka and Santa Fe Railroad.

The Pacific districts embrace all of the mountainous region from the Great Plains to the Pacific, and are divided laterally by the Union Pacific and Central Pacific Railroads. Accidentally the aggregate of the northern and southern districts vary but little in area, the former being 1,524,700, and the latter 1,534,060 square miles. (For areas see sketch-map herewith.) At least one central point can be selected in each of the eight areas from which to direct the operations of a survey and most convenient of access to all prominent points. Independent of the land subdivisions, belts of detailed topography are needed for the common defense, and the comprehensive detailed survey of all the navigable waters of the United States, those suggested for the several districts, is as follows: In the Atlantic districts the final establishment of geodetic points in each county, the belts of triangles to be checked by necessary astronomic points and the measure of all water and land routes of transportation. The same applies to the Mississippi districts. The districts of the plains first require detailed meander surveys of all the routes and streams checked by astronomic stations with geodetic connections to follow as the country becomes more thickly settled and the States take up the more detailed topographic and geologic surveys. The Pacific districts should first be covered entirely by a topographic survey similar to that prosecuted for the ten years ending June 30, 1879, by the War Department, and an estimate of the cost of completing which is given in inclosures No. 3 to Senate Ex. Doc. No. 21, Forty-fifth Congress, third session, while for the more thickly settled portions topographic works resting on first-class geodetic basis are the only ones that should be prosecuted.

To secure uniformity and simplicity in the map the modified secant conic projection is suggested that has been employed successfully upon the geographic surveys of this office. The number of rectangles of the same size as those into which the area west of the 100th meridian was divided in 1872 is 210. The approximate size of a rectangular area for the middle latitudes is 150 miles east and west by 120 north and south, or 18,000 square miles or 11,520,000 acres. The size of each printed sheet is 19 by 24 inches. The projection admits of the conjoining of sheets. When parts only of an entire rectangular subdivision are to be mapped the same projection can be applied upon different scales and the size of the sheets varied at will. The limit of the Government surveys in the older States being to the establishment of latitudes, longitudes, and altitudes and measurement of railroad, canal, and other routes of communication, and the first topographic survey, the resulting sheets may be turned over as produced to the States about to prosecute a more detailed topographic survey or the continued examination of its geological structure and mineral products.

Upon a scale not less than 1 inch to 4 miles for territory east of the Mississippi, nor less than 1 inch to 8 miles west of that line, the projections of the number of sheets required for the whole United States should be begun, upon which should be compiled and delineated all known longitudes and latitudes of importance, and sufficiently accurate geographical material resulting from original surveys heretofore and hereafter to be made should be added at a permanent office of the War Department to be designated by law for all time. These sheets when completed and conjoined would constitute the great final topographic map of the union of States.*

The area, population, etc., of the districts is as follows:

Number.	Name.	Area.	Population 1870.	Per square miles 1870.	Population 1880.	Per square miles 1880.	No. of Senators.	No. of Representatives.	No. of electors.
		Sq. m.							
1	Mountainous or Pacific district (north)	616, 220	595, 769	1.2	626, 994	1.25	4	3	7
2	Moun ainous or Pacific district (south)	584, 088	562, 244	1.0	1, 045, 924	1.8	4	6	10
3	District of the plains (north)	347, 227	495, 316	1.4	1, 150, 973	3.3	3	7	10
4	District of the plains (south)	356, 322	922, 536	2.6	2, 100, 220	2.8	3	14	17
5	Mississippi Valley district (north)	479, 433	13, 275, 065	22.3	15, 482, 879	32.3	17	102	119
6	Mississippi Valley district (south)	351, 165	7, 211, 087	18.9	10, 177, 105	28.7	13	65	78
7	Atlantic district (north)	106, 704	12, 630, 400	72.2	14, 983, 850	80.1	22	94	116
8	Atlantic district (south)	182, 461	3, 454, 968	17.9	4, 561, 819	25.3	10	32	42
		3, 025, 600	38, 558, 371	12.7	50, 155, 783	16.6	76	325	401

NOTE.—The approximate area given by the tenth census of the States and Territories excluding area of water surface (approximately 55,000 square miles) is 3,025,600 square miles, or 2,970,000 square miles of land surface. The total length of sea-coast line from headland to headland is approximately, Atlantic, 16,000 miles; Gulf, 2,086 miles; Pacific, 1,365 miles; Alaskan, with the larger sounds and bays, but exclusive of the Aleutian Islands, 7,800 miles, independent of bays, sounds, etc., that aggregate 4,900 miles for the Atlantic, Gulf, and Pacific. The coast within the United States of Lakes Superior, Michigan, Huron, Erie, and Ontario aggregate 4,250 miles in length.

The total population as given by the census of 1880, exclusive of Alaska (33,426), was 50,155,783, or an average of 17.29 per square mile, excluding the Indian Territory, and of the area of settlement estimated at 1,569,570 square miles, an average of 32 per square mile. The largest average per square mile in any State in 1880 was 254.9 for Rhode Island, with Massachusetts next at 221.8, and the least, .20 per square mile, for Wyoming, while the Territory of Utah shows 1.63, those of Arizona and Idaho .04, and Dakota .06 per square mile.

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* This mother map should then be developed specifically to meet all economic and industrial requirements, the latter particularly by the States, after a general examination of the structure and resources of the whole country.

If we are to have these maps (military, economic, and scientific), as have them we must, they

The cost of a geographic and topographic survey of any part of this area can be made to vary from $1 to $1,000, or even a much greater sum, per square mile. Estimates of the ordnance survey of England, still incomplete, show its cost to be more than $200 per square mile. The cost of our own coast and lake surveys has reached considerable amounts that are, however, no absolute criterion, as the elaborate bases and networks of triangulation established for a narrow belt of hydrography and topography would answer in the interior for a much greater area, and the details required in reference to inland topography may be varied indefinitely. The cost per capita of an elaborate survey of the entire country comparable with that of the home Government of England would be great, and if conducted with ill-defined powers and bad management might easily exceed the value of the entire landed properties of the Union, and without results in the least degree commensurate.

It is plain when the great area of the country is considered in connection with the comparatively small average of population, and coupled with the fact that a great part in the West is still substantially an unoccupied mountainous wilderness, that the Government is not yet prepared to commence, except for selected areas, interior surveys after the elaborate detailed and costly plans of Great Britain and the older and more populous nations.

TOPOGRAPHIC.

ORIGIN.

In England the great general or topographic survey may be said to have commenced with the measurement of the Hounslow Heath base, under

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will result from a practical application of all known scientific principles and methods to the work in hand while constantly consulting the current and permanent wants of the Government and people.

The preserving, protecting, and defending functions of the war branch of the public service have no single better field of operations in an interval of peace than in collecting all known information bearing on military operations in detail for our own country, and generally for that of our neighbors.

From all survey works in the past, from those of the present, as well as the future, wherever lodged as to administration or execution, every particle of critical data bearing on latitudes, longitudes, and altitudes should be constantly availed of by the War Department and compiled into a systematic descriptive list or tabulation of this data for the whole United States, including description of monuments and bench-marks, which should then be entered on skeleton map-sheets, the groundwork of a permanent military topographic atlas of the whole country such as heretofore mentioned.

General Roy, Royal Military Engineers, in 1784, the triangulation for the (military) topographic map dating from 1791.

Prior to the organization of the several German states into the present Empire the general land or topographic surveys were prosecuted independently. In Prussia, prior to 1816, there existed only the desultory works of a few administrative departments of the Governments and individuals, at which date these map works were transferred from the statistical bureau of the finance department to the general staff of the army, where they have since remained. In 1864 the more systematic topographic survey of the six eastern provinces of Prussia was established, and in 1870 the new general map, scale 1:100,000—674 sheets—was projected.

Triangulation was begun in 1781, followed by detailed topography in 1785.

The oldest manuscript map found mentioned of Saxony dates from 1531. The survey of the country was first encouraged by August, the Elector, and conducted by members of the Oder family from 1550 to 1600, publications therefrom being prevented. The first map seems to have been printed in 1568, and to have been used with revisions for over two hundred years.

The Aventine map of Upper and Lower Bavaria, 1523, that by Apian, 1536, are the first known, and were used for over two hundred years. The first Bavarian atlas was projected by Bonne (in 1801), an officer of the French general staff (état-major), detached for this purpose. The general staff of the Bavarian army has systematized and prosecuted this work without intermission since 1817.

The first known map of Wurtemburg is one by Stoffler (1542, unpublished), which was accidentally burned in 1534. The oldest known published map was issued at Tubingen in 1559. The first trigonometric observations began in 1793. Systematic triangulation dates from 1818.

Trigonometric and topographic works in Baden began in 1812-'14, under Colonel Tulla, chief of the corps of military engineers.

International Commission.—General Baeyer's project, "the degrees measurements of Central Europe," was sanctioned by the Prussian Government

June 20, 1861, and a central bureau was established at Berlin in connection with the Geodetic Institute, with General Baeyer at its head.*

The earliest known atlas of the Austrian domain consists of eleven wood-cuts, dated 1561. The oldest geometric maps of Austria date from the seventeenth century. Triangulation began in 1762.

The military topographic bureau of France dates from 1688, and has been in continuous existence ever since.

The Dufour military survey of Switzerland commenced in 1830.

Astronomic and trigonometric observations for a general topographic map of Holland were begun in 1802 by General Krayenhoff, inspector-general of fortifications and of the corps of engineers.

Systematic topographic surveys as an aid in defense against all invaders were only begun in the Dutch East Indies in 1849, in the territory between Batavia and Buitenzorg, prior to which there were none but defective maps.

Triangulation seems to have begun in Spain in 1855.

In Italy, prior to the consolidation in 1861, the Italian state governments prosecuted separate surveys dating from about 1815. Austria controlled in the northern part of Italy till 1866.

The first map of Sweden appears to have been executed in 1539, and the first engraved map in 1626. Surveys of different grades have been going on for over two hundred years. The first complete map was issued about the year 1800. The oldest known triangulation is 1758.

A map of the Inlet of Ide, in Norway (scale approximately 1 : 50,000), appeared in 1661. A description of parishes was begun in 1706, and a general map of Norway appeared in 1761. The military topographic survey was ordered in 1773.

The oldest geographical knowledge of Russia, consisting of descriptions of real estate by the fiscal agents of the Mongolian occupation, dates from the middle of the thirteenth century.

The first general map of Russian territory, now lost, was made about the middle of the sixteenth century, and called "The Great Drawing." A printed map of Russia, published 1614 at Amsterdam, with Latin inscription, is found in the scientific military archives of the general staff bureau at St. Petersburg. Peter the Great was the first to fully realize the necessity of an accurate geographic knowledge of the Empire. He ordered the execution of surveys, preparation of maps, description of territory by districts in 1720, and made it a part of the duties of the office of the quartermaster-general to collect all needful information in regard to military topography and roads over which to move armies. Triangulation scientifically conducted began in 1816 in Russia.

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*After General Baeyer's death (1886) it was no longer connected with the Geodetic Institute, but is maintained at the cost of the several states as an international association, consisting of a president, nine associates, also the director of the central bureau and Geodetic Institute.

The trigonometric operations for a topographic survey of Belgium date from 1844.

The oldest noted map of Denmark bears date of 1550; another one was issued between 1638 and 1652. Triangulation commenced in 1762. The organized military survey dates from 1809.

Geographic works have long been fostered by the Government of Portugal, and topographic works resting on a trigonometric basis were begun at the close of the eighteenth century.

Surveys on the coast of what is now called British India began about 1600. The first map mentioned is the one by D'Anville in 1754. Route surveys began in 1763. Triangulation was introduced about 1800.

Instrumental topography may be said first to have been undertaken for the Government of the United States shortly after the Louisiana purchase by the expedition of the army officers, Lewis and Clarke, from the Mississippi River to the Pacific Ocean, set on foot by President Jefferson, in pursuance of a specific confidential grant of money by Congress.

ADMINISTRATION.

The administration is that of the war department for Germany, Austria, France, Switzerland, Holland, Dutch East Indies, Italy, Sweden, Belgium, Denmark, and Norway; office of works in Great Britain, with a mixed personnel of military and civilians, with a major-general in charge; in Spain under the department of public works, with a field-marshal general in charge; in Portugal under the department of public works, with a brigadier-general at the head; in British India as a branch of the department of revenue and agriculture, with a lieutenant-general in charge.

ORGANIZATION.

Much correspondence with foreign government offices and search at many important libraries sufficed to find only twenty distinct topographic survey organizations, distributed as follows: (1) United Kingdom, at Southhampton, England (under a major-general until 1883, the present director-general being Col. R. H. Stotherd, royal military engineers): (2) Prussia, at Berlin (in charge of Major-General Regely, of the general staff); Saxony, at Dresden (in charge of Colonel von der Planitz, chief of the general staff); (4) Bavaria, at Munich (in charge of Colonel von Orff, of the general staff); (5) Wurtemberg, at Stuttgart (in charge of President Von Schneider, of the statistical topographic bureau); with Col. H. Bach as chief of the topographic branch; (6) Baden, at Carlsruhe (in charge of Lieutenant-Colonel Schneider, of the Prussian general staff); (7) Austria, at Vienna (Maj.-Gen. Joseph Baron Wanka von Lenzenheim, director); (8) France, at Paris (in charge of Colonel Perrier, of the general staff; (9) Switzerland, at Berne (in charge of Col. J. J. Lochman, corps of engineers); (10) Holland, at The Hague (office, only, in charge of C. A. Eckstein, director, under the chief of the general staff, a major-general); (11) Dutch East Indies, at Batavia (in charge of Major Meyer); (12) Spain, at Madrid (in charge of Field Marshal Charles Ibañez de Ibero, corps of engineers); (13) Italy, at Florence (in charge of General Charles Gené); (14) Sweden, at Stockholm (in charge of Col. Victor von Vegesack, of the general staff); (15) Norway, at Christiana (in charge of Col. C. G. With, chief of the general staff); (16) Russia, at St Petersburg (in charge of Major General de Forsch, general staff); (17) Belgium, at Brussels (temporarily in charge of Maj E. Hennequin, of the general staff); (18) Denmark at Copenhagen (in charge of Maj. Gen. L. E. Fog, chief of the general staff); (19) Portugal, at Lisbon (in charge of Brig. Gen. Carlos Ernesto de Arbués Moreira); and (20) India, at Calcutta (in charge of Lieut. Gen. J. T. Walker, royal military engineers, as surveyor-general).

With the exceptions of the Topographical Institute at The Hague (the functions of which are confined to the office, and are more or less technical and connected with reproduction of maps), and the statistical topographic bureau at Stuttgart (the duties of which are more statistical than topographic, the latter branch having, however, an officer of the army as chief) the field and office operations are in charge of and directed by officers of military engineers, or of the general staff of the army of the several ranks of major, colonel, brigadier, major, and lieutenant general and field-marshal.[*]

In England the organization has from the first been known as the "ordnance survey," with an officer of the royal military engineers as director-general, with the rank of lieutenant-general or major-general, until 1883, when a colonel was placed in charge. It now consists (1885) of 30 officers, 128 non-commissioned officers, and 229 soldiers of the royal engineers, 1,962 civilian assistants of various grades, and 934 laborers, numbering 3,283 in all.

The main office at Southampton, in charge of the director-general, has the following divisions:

(1) Administration, correspondence, and accounts.
(2) Examination of manuscript plans, reduction and drawing of maps for engraving, photozincography, letter-press printing, and electrotyping.
(3) Trigonometric branch.
(4) Engraving general topographic maps on copper, plate-printing, and coloring maps.

A special boundary office is found at London and ten sub-offices throughout England; also one at Edinburgh for Scotland; another at Dublin for Ireland; the latter for publication, engraving, and revision.

In Prussia the state land survey (Landes-Aufnahme) is in the charge of a special chief (a major-general), under the chief of the great general staff (état major-général) of the army at Berlin. It consisted July, 1885, of 93 officers of the general staff, engineers, and of the army, 408 technical officials, and 39 clerks, messengers, etc., or 540 persons in all.

There is a central (deliberative and consultative) commission of surveys in Prussia, presided over by the chief of the great general staff, now Field Marshal Count von Moltke.

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[*] There have existed for the prosecution of topographic works, at least, the following specially selected corps of officers, known in France as "engineer geographers" and "military geographical engineers" (1696 to 1831), as "military engineer geographers" in Austria (1851 to 1861), and "military topographical engineers" in Russia (1822 to date), and the Corps of Topographical Engineers in the United States from March 3, 1813, to March 3, 1863.

This commission is composed of representatives from the following bureaus of the several ministries:

Treasury: Public domain, forests, and forestry; direct taxes.

Commerce: Administration of railways, land and water improvements, and communications.

Agriculture: Communal division and amelioration of land.

Public instruction: Geodetic Institute.

War and general staff: State survey and geographic statistical division of the general staff.

Marine: Hydrographic office and survey of the coast.

The minister of the interior, in addition to the above, is entitled to a representative on this commission.*

The general state land survey, with its main office at Berlin, has four principal divisions, as follows:

The general office (semi-administrative and executive in its control), consisting of 47 officers of the army, 208 technical officials, 30 clerks, messengers, etc, and subdivided as follows:

(1) *Trigonometric division.*—Section I: Office of the chief, repair and supervision of instruments and means of transportation, correspondence, purchase of ground for monuments. Section II: Principal triangulation. Section III: Triangulation of second class. Section IV: Detailed triangulation. Section V: Leveling and altitudes. Section VI: Publication, archives and library.

(2) *Topographic division.*—Section I: Office of chief. Section II: Preparation for field operations, care and repair of instruments, archives and library. Section III: Reconnaissances. Section IV: Field survey sections.

(3) *Cartographic division.*—Section I: Office of chief, archives and library. Section II: Drawing of map 1:100,000. Section III: Publication of map 1:25,000. Section IV: Revision of original maps. Section V: Revision on stone. Section VI: Copper engraving. Section VII: Printing. Section VIII: Photographic institute. Section IX: For general and staff purposes.

The triangulation work required by this most systematic of surveys is the first duty of the organization, and proceeds independently, although adopting, when convenient, any of the lately verified triangulation, conducted by the Prussian members of the international commission for "European degrees measurements," under General Bäyer, a retired officer of the general staff, and formerly chief of the "Landes-Aufnahme."†

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* The bureaus of mines and mining and of the geological examination of Prussia are not represented on this commission.

† The great general staff of the Prussian army, traces of which date back as far as the Brandenburg army under the great Elector, consisted in 1875 of 147 officers of all grades, with 40 other officers

In Saxony the topographic work is carried on by the general staff of the army, with a colonel of the general staff (état-major) in charge.

In Bavaria the topographic survey has been conducted continuously by the army general staff since 1817. The present director has the rank of colonel.

The statistical topographic bureau of Wurtemberg, with a small topographic office at Stuttgart, consists of 1 director, 1 honorary, 9 ordinary, and 2 extraordinary members, with 17 assistants, with a civil head, only a small number of whom, under the direction of an army officer, are engaged on topography. A consultative commission, with delegates from the ministries of justice, the interior, education, and war, are superior functionaries of this bureau. The trigonometric and topographic works of Baden (with main office at Carlsruhe) are conducted by a lieutenant-colonel of the Prussian general staff

In Austria-Hungary the present organization of the Military Geographical Institute, a branch of the general staff of the army, at Vienna, consisted in 1881 of 296 officers, 190 technical officials, and 300 non-commissioned officers, soldiers, and day workmen, 786 in all, with a major-general at its head. The military surveys in Austria during the last half

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attached for one year's duty. This body has had since 1821 an independent position, subject alone to the control of the commander-in-chief (now the Emperor of Germany). General Field Marshal Count von Moltke has held the position of chief since October 29, 1857.

Its duties are the management of all questions concerning its personnel and arrangement of duties therefor, the continual development of military knowledge concerning both Germany and other countries, the use of railways, the compilation of military history, the promotion of military science, maps, the great topographic survey of the country, etc.

For strategic purposes there are three sections, to each of which are allotted a given number of countries, the duties of each of which are to attentively follow all military innovations at home and abroad, keeping informed of all matters concerning military organizations, reserves, the armament and equipment of armies, the military geography of countries, the construction or removal of permanent fortifications, the development of railways, roads, canals, etc.

The fourth section is that for railroads. Its special duty is to keep informed of everything that affects the subject of military transport, and to possess and maintain an accurate knowledge of all railway systems both at home and abroad, together with their capacity for traffic, and to plan large military transport arrangements, etc.

The military history section has charge of the records and the library. A geographic statistical section is charged with the preparation of foreign military maps, and a special and independent branch has charge of everything connected with the great general survey. There is no army of Continental Europe without its general staff, engaged in specific duties and with a selected personnel drawn from the most able and meritorious officers of the army at large. (See "The Duties of the General Staff, by Maj. Gen. Von Schellendorf," translated by W. A. H. Hare, lieutenant of royal engineers, London, 1877.)

of the eighteenth century were conducted under the quartermaster-general, and the land survey has been exclusively executed by officers of the army, who had also hitherto been detailed for geodetic operations.

The following, taken from the year-book of 1881, shows the divisions of the organization.[*]

Group 1.—Direction of the institute.

Group 2.—Astronomic geodetic division.

Group 3.—Mapping: (*a*) military land surveys; (*b*) military drawing division.[†]

Group 4.—Topography: (*a*) chief; (*b*) topography; (*c*) special map drawing division; (*d*) lithography; (*e*) copper engraving; (*f*) correction and revision of maps.

Group 5.—Technical: (*a*) chief; (*b*) photography and chemigraphy; (*c*) heliogravure; (*d*) photolithography; (*e*) presses, bookbinding.

Group 6.—Administration: (*a*) chief; (*b*) archives; (*c*) accounts; (*d*) non-commissioned officers.

Group 7.—Cadastral division.[‡]

The military topographic bureau of the war department of France was established in Paris 1688, where it has since continuously existed. A corps known as "engineers of camps and armies" was established in 1696, which was changed to the designation of "engineer geographers of camps and armies" in 1726, and to which a more stable status was given in 1744. In 1760 the engineer geographers were separated from the bureau of fortifications, and in 1761 consolidated with the "dépôt des cartes et plans." By ordinance of 1776 the above body was associated in service with the military engineers, and in 1777 the title of "military geographical engineers" was conferred. In 1791 the functions of the latter were merged with those of the military engineers. A final reorganization was effected in 1799, with a special bureau directly under the First Consul. Topographic surveys were carried on by the "engineer geographers" until their disbandment in 1831, when they were taken up and carried to completeness by the "État-Major." The name of the central office in Paris has been "dépôt de la guerre," and for which the title "service geographique" has been given to the new surveys and revisions of the mother topographic map. The present head of this branch of the service has the rank of colonel.

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[*] The total personnel of this institute in 1876 was 1,258. (See Comstock, "Notes on European Surveys," p. 48.) There existed in Austria from 1851 to 1861 a specially selected corps of "military engineer geographers," disbanded, however, upon the reorganization of the general staff in 1861.

[†] This includes a military drawing-school for selected officers and non-commissioned officers.

[‡] The above establishment is a direct outgrowth of the "Deposito della Guerra" of the Cisalpine Republic, created at Milan about the year 1800, when a military topographic corps, called "engineer geographers," was formed, to which were attached officers of the engineer corps (Corps du Génie) of the Franco-Italian army. After the Austrian occupation of 1814 the above was continued under the name of "Instituto Geographico Militare." This office was transferred in 1839 to Vienna, and perpetuated substantially under its present form.

The organization having charge of the topographic work in Switzerland is located at Berne, and is known as the "federal topographic bureau of the general staff," with a colonel of military engineers in charge. It consisted in 1875 of engineers, engineer topographers, draughtsmen, engravers, lithographers, and printers, the number varying according to the means annually at disposal.

In Holland a number of officers of the general staff of the army, under the head of that bureau, conduct the topographic work in the field and prepare the result for publication, while the Topographic Institute, with Mr. Eckstein as director, under the same authority, has charge of the reproduction of all maps for the war and other ministries of the Government.

The topographic bureau of the Dutch East Indies at Batavia is under the charge of an officer ranking as a lieutenant-colonel or a major of the army.[*] The service consists of (A) the "direction," embracing the chief, one captain, one or two first or second lieutenants (adjutants)—the lieutenants do not belong to the general staff, but may be drawn from all branches of the army; (B) the "survey brigades," four captains (chiefs), four first or second lieutenants, six adjutants, eight sergeant-majors, twelve European sergeants, eight European corporals, eight European apprentices (soldiers); a "triangulation division," with one major or captain (chief), two captains, two first or second lieutenants, one military surveyor (each of first, second, and third class), one adjutant, two sergeant-majors, and three sergeants; (C) the "topographic office," thirteen adjutants, sergeant-majors, European sergeants, corporals, apprentices (soldiers), draughtsmen, and eighteen native draughtsmen (first, second, and third class); (D) the "photographic division," one photographer and two assistant photographers (military surveyors and soldiers); (E) a "lithographic division and instrument workshop." Civilians are eligible alone to the photographic, lithographic, and instrument workshop divisions.

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[*] Examinations are held for officers and assistants, which must be satisfactorily passed before admission to this service. In 1873 the topographic service was transferred from the engineer department to the general staff.

The Geographic Statistical Institute at Madrid is under the charge of an officer of the corps of engineers (Field Marshal Ibañez), who is assisted permanently and by detail by officers of engineers, artillery, and the general staff, engineers of "ponts et chaussées," of mines, and of waters and forests, of astronomers, a corps of topographic engineers (officers and topographers), and geodetic aids. All military officers and civil engineers while employed on this duty receive extra compensation therefor.

At the same time the general staff of the war department of Spain is engaged in the preparation of maps, making reconnaissances, etc.

The topographic works in Italy are carried on by the Military Geographic Institute at Florence, a branch of the general staff of the army, but with power of independent action and self-control. It is composed of officers of the general staff, military engineers, officers of artillery, cavalry, and infantry, technical and clerical assistants, and a number of selected enlisted men.

The topographic section of the army general staff has charge of the land surveys in Sweden. In 1806 the Swedish field surveying corps was established, embracing duties hitherto done by the royal fortification corps and army at large, with a definite organization. In 1811 this branch was merged with the fortification corps under the name "the royal engineer corps," divided into the fortification and field survey brigade. The topographic part was separated and organized independently in 1831. Since January 1, 1874, the topographic corps has been dissolved and united with the reorganized general staff, with constitution as above.

The military geographical survey of Norway is conducted under the Geographical Institute at Christiania, which resulted from merging the geographical survey of the interior department with the topographic section of the general staff (état-major).

In 1828 the survey was named the "combined topographic and hydrographic survey," which became in 1833 the "royal Norwegian geographical survey," which was again changed to that of "Norwegian geographical survey," which was consolidated as above with the topographic section of the general staff (état-major). Independent of the general staff, officers of the army and navy are specially detailed for a period of service in the field and office.

The personnel is divided in the following sections, independent of an accounting branch:

(1) Trigonometric-photographic section (its chief being a captain of the general staff).

(2) Detailed surveys and map publications (chief, a captain of the general staff).

(3) Hydrographic section (chief, a specially assigned naval officer).

(4) Engraving and printing (chief, the lithographer of the general staff).

(5) Photographic galvanoplastic section (chief, the photographer of the general staff).

The general staff in Russia was organized in 1763, and route maps were prepared by its officers during the latter part of the eighteenth century. The imperial office of draughtsmen was created in 1796, and in 1797 converted into the imperial depot of charts. The collection of maps, hitherto in the engineer and quartermaster-general's departments, were transferred to this depot, which was officered by detail of superior and subaltern officers of engineers and from the army, in charge of a major of the engineer corps. In 1812 the depot of charts became the military topographic depot, directly under the minister of war, and was afterwards (in 1816) placed under the chief of the general staff, the topographic section of which it still remains. In 1822 a corps of topographical engineers, unlimited as to numbers, to carry on systematic works was established as a branch of the imperial general staff, and a body of selected soldiers with a school for topographic instruction. This body was limited to 70 officers and 456 topographers in 1832, and the school received an entirely military organization. This corps was again reorganized in 1866, the personnel being fixed at 6 generals, 33 superior officers, 156 subalterns, 170 topographers with civil rank, 236 topographers with rank of corporal, and 42 apprentices, making 643 in all.

The Military Cartographic Institute of Belgium, at Brussels, a branch of the general staff, was in 1882 temporarily in charge of a major of the general staff, its former head, with the rank of colonel, having lately deceased. The topographical engineers are taken from the older pupils (subaltern officers) of the military school, twelve or fifteen of these officers forming a brigade of the état-major. The reproduction branch consists of draughtsmen, lithographers, engravers, photographers, and printers.

The topographic section of the general staff at Copenhagen has charge of the "military geographic map" of Denmark.

The general staff was established in 1808, and took charge of the above work in 1830, and to which all the map work hitherto in the hands of the Royal Scientific Society of Denmark was transferred in 1843, where it has since remained. The work is performed partly by officers of the general staff and partly by other officers of the army detailed therefor. This office was reorganized and largely increased in 1867.

In Portugal (unlike any other country) the trigonometric, topographic, hydrographic, and geological works are united under one direction, which was created in 1856. The bureau for this branch of service at Lisbon is divided into five classes of duties, as follows:

(1) Geodetic (main triangulation, etc.) works.
(2) Topographic works.
(3) Hydrographic works.
(4) Geologic works.
(5) Artistic works and administration.

The present great survey of India has resulted from the amalgamation (January 1, 1878) of the former organizations styled trigonometric, topographic, and revenue surveys under a single administrative and executive head, the surveyor-general, with a personnel in 1882 (according to the "India List") of 44 military officers and 160 civil assistants.

No organization for the prosecution of systematic general topographic surveys exists in the United States. The Geological Survey, organized by statute in 1879 for purely geological purposes, with the following words of an appropriation act as authority, "to continue the preparation of a geological map of the United States," is carrying on topographic field operations at widely divergent localities in the older as well as the newer States, from a geologic standpoint, *i. e.*, based on triangulation "sufficiently correct" only for the scale of the map employed, and with undue weight attached to the topographic relief of the natural features as compared with the details of communication and artificial and economic features of the ground.

The Coast Survey has executed a narrow strip of topography along the Atlantic, Gulf, and Pacific coast lines, where its surveys are complete, usually to the first crest-line within view of the nearest navigable channel of approach, and the same may be said, in a general way, of the Lake Survey of the great northern lakes, as regards their lines of coast. By a special grant the Coast Survey is carrying on triangulation near and along the thirty-ninth parallel to connect its trigonometric belts along the Atlantic and Pacific coasts.

The Mississippi River Commission adds a strip of topography, including the stream and its banks.

Prior to the establishment of the Geological Survey various temporary organizations under the Interior Department had been operating at different times since the war of the rebellion in the regions west of the Mississippi River, known as the "Geological and Geographical Survey of the Territories" and of the "Rocky Mountain Region," and the "Geological Exploration of the Black Hills," all controlled by the theoretical considerations of the geologist. The "geological exploration of the 40th parallel," under the engineer department, conducted its labors on a similar basis, while the "geographical survey of the territory west of the 100th meridian," under the same department, proceeded from almost a diametrically opposite standpoint, giving due weight to the astronomic, geodetic, and topographic observations, with map delineations of all natural objects, means of communication, artificial and economic features, the geologic and natural history branches being treated as incidental to the main purpose.

The latter may be considered as the only organized systematic general geographic and topographic work (both scientific and practical) ever begun by the General Government in the interior of the country.

Just as its organization (consisting of officers of engineers of the Army, selected general service and other enlisted men, civilian assistants, clerks, messengers, etc.) was brought to a high state of efficiency (through training and experience) the appropriations were suspended. Geology in organic form was established in the Interior Department, the vastly more important work of topography was disregarded and left unprovided for, and the services of practical and experienced Government engineer officers thus lost for this latter duty, resulting in a direct and positive step backward, without precedent throughout the civilized world.*

FUNCTIONS.

Since general relief surveys of the land were instituted in England the ordnance survey has had sole and undisputed charge of the astronomic, base measuring, trigonometric, topographic, hypsometric, and cartographic operations therefor.

The following are the principal works at present in progress:

(1) The final preparation and publication of the new topographic map series for the whole United Kingdom, scale 1 inch to 1 mile, in 696 sheets.

(2) Surveys for and the final preparation and publication of the 6-inch scale or county maps for the United Kingdom in, approximately, 13,391 sheets.

(3) Surveys for and the preparation and publication of the cadastral or parish maps for the entire United Kingdom (25 inch), scale 1 : 2,500. Sixteen of these sheets make one of the 6-inch engraved maps. The approximate number is 51,488 sheets for England when complete, and for Scotland 12,316 sheets.

(4) Survey for and the preparation and publication of (scale 1 : 500) plans of cities and all towns over 4,000 inhabitants, except London and environs, which latter is at the scale of 60 inches to the mile.

The duties imposed upon the office for the great general survey of Prussia (Germany) comprise the field and office operations necessary to the successful prosecution of the astronomic, base measuring, trigonometric, topographic, hypsometric, and cartographic works required by the war and all other departments of the Government, except for the *cadastre*.

The principal works now in progress are the following:

(1) The plane table and station work necessary for the topographic sheets, with their final preparation and publication on scale 1 : 25,000 (3,698 sheets) for all of Germany, except Saxony, Bavaria, Wurtemberg, and Baden, the yearly area to be surveyed being fixed at 200 German square miles (approximately 4,400 square English statute miles), the trigonometric, topographic, and cartographic results following each other

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* The subject of scientific surveys was examined by a joint Congressional commission during the 48th and 49th Congresses, and their report, after hearing voluminous evidence, forms Senate Report No. 1285, Part 1 and Part 2, 49th Congress, first session. The majority report leaves the Coast Survey and Hydrographic Office subtantially in *statu quo*, and sustains the extension of the Geologic Survey with certain restrictions, and does not favor the establishment of a scientific commission to take charge of the general direction of all scientific work under the Government, whereas the minority report recommends the transfer of the Coast Survey proper to the Hydrographic Office of the Navy, and the restriction of the Geologic Survey in field, office, and publication work. The result of this commission had no bearing on legislation, except to regulate Geological Survey publications, and indirectly upon appropriations. The whole subject remains in an inchoate and unsettled state.

in quick succession. The special scale of 1 : 12,500 is used for the vicinity of garrisons and maneuver districts.

(2) The preparation and publication of 554 of the 674 sheets of the new topographic map of Germany, scale 1 : 100,000.

(3) The keeping "au courant" of older surveys, with field observations therefor, construction of special maps, and revision of various Government maps, such as are now being issued. (See lists of maps.)

(4) To develop, pursuant to the demands of modern scientific warfare, the cartographic work necessary for military purposes, as well as to supply the economic maps required for industrial purposes.

The topographic survey of Saxony (with its trigonometric, topographic, leveling, and cartographic divisions) is at present specially charged with the surveys for the preparation and publication of a map (from plane table sheets) of Saxon territory, scale 1 : 25,000, in 156 sheets.

Likewise Bavaria and Wurtemberg make similar maps of same scale, after a plan for all Germany somewhat uniform with 990 and 192 sheets, respectively.

The above countries contribute to the general map of Germany scale 1 : 100,000, Saxony 30, Bavaria 80, and Wurtemberg 20 sheets, and issue various topographic maps, generally on minor scales.

In Baden there is a special topographic survey for a map 1 : 25,000 in 170 sheets in progress, which contributes to form a part of the general map 1 : 100,000 of Baden's territory constructed at Berlin.

The Military Geographical Institute at Vienna has had full and uninterrupted control of all the topographic works of Austria-Hungary resting on a trigonometric basis with precise leveling operations, of which the principal ones now are—

(1) Field work for plane table sheets of the whole territory, scale 1 : 25,000, which so far remain unpublished.

(2) The construction, preparation, and publication of a new topographic map scale 1 : 75,000, in 720 sheets.

(3) The cadastral survey (based upon a number of trigonometric points) of Bosnia and Herzegovina.

(4) Continuation and enlarging the map (1 : 750,000) to embrace Germany, Belgium, Holland, Eastern France, Western Italy, revision of map of Central Europe (scale 1 : 300,000), preparation of recruiting maps (scale 1 : 1,000,000), correction and revision of all special maps.

In France the "dépôt de la guerre" (geographical service) of the war department has exclusive jurisdiction and control of the fundamental operations demanded for the principal or mother topographic map of the country, its main works being as follows:

(1) Revision, once in each five years, of the topographic map of France, scale 1 : 80,000, 273 sheets.

(2) Field and office operations necessary for the preparation and publication of the new topographic map of France, scale 1 : 50,000, 1,092 sheets (original field minutes, scale 1 : 40,000).

(3) The new surveys required for the construction and publication of the topographic map of Algeria, scale 1 : 50,000, approximately 327 sheets.

(4) Reduction of the map of 1 : 50,000 to the scale of 1 : 200,000 for the topographic map of France, scale 1 : 200,000, 81 sheets.

(5) Corrections and revision of the great variety of planimetric and topographic maps of France issued by this branch of the war department.

The fortification branch issues its separate map (scale 1 : 500,000), and also maps on scales 1 : 1,000 and 1 : 2,000 for more exact studies, making, however, nothing further than local surveys, while the ministry of public works issues a compiled map for specific purposes, scale 1 : 200,000, and the ministry of the interior also another compilation on scale 1 : 100,000 (each taking advantage of local surveys under its own direction).

The Federal Topographic Bureau of Switzerland is charged with all the field and office operations (astronomic, trigonometric, leveling, topographic, and cartographic) necessary and incident to the full measure of the topographic survey, its main duties at present being—

(1) The constant revision and reissue, as required of the Dufour topographic map of Switzerland, scale 1 : 100,000, 25 sheets.

(2) The field surveys and office reductions necessary for the new detailed topographic map of Switzerland, scales 1 : 50,000 and 1 : 25,000, of 119 and 442 sheets, respectively (16 sheets, scale 1 : 50,000, and 64 sheets, scale 1 : 25,000, each, make one sheet of Dufour map, scale 1 : 100,000).

(3) Preparation and publication of a general map of Switzerland in 4 sheets, scale 1 : 250,000, as well as corrections and revision for a number of standard Government maps.

The Topographic Institute of Holland, under a director subordinate to the chief of the general staff, has charge of the reproduction of all the general topographic maps of the country, the latter having direct charge of the field surveys, including the usual main and minor operations therefor.

The present duties of the general staff include—

(1) The correction and revision incident to the new editions of the topographic map of Holland, scale 1 : 50,000, 62 sheets.

(2) Revision of the chromo-lithographic map of the "Ponts et Chaussées," scale 1:50,000.

(3) New chromo-lithographic map of Holland, scale 1:25,000, in 776 sheets (confidential publication).

(4) Map of the principal rivers of Holland, scale 1:10,000.

(5) Chromo-lithographic atlas of the residences of Java, scale 1:100,000.

(6) Atlas of the Dutch East Indies, 14 sheets.

The field work of the survey and office reductions, including construction of maps for the Dutch East Indies, take place under the officer in charge of the Batavia office, while the field observations for the new topographic map of Holland are made entirely by selected officers of the army.

The current works of detailed survey now being prosecuted are—

(1) Residence of Banjoewangi, scale 1:40,000, title, index, and 4 other sheets (photo-autography).

(2) Residence of Preanger Regency, scale 1:20,000, title, index, and 4 other sheets (photo-autography).

(3) Above in 1 sheet, scale 1:50,000.

(4) Division of Deli, residences east coast of Sumatra, scale 1:100,000, 7 sheets.

(5) General map of Madura, in colors, scale 1:100,000.

(6) Various residences, scale 1:20,000.

(7) General maps, etc., scale 1:100,000.

(8) Various residences, Preanger Regency, 2 sheets, scale 1:300,000.

The Geographical Statistical Institute of Spain comprehends all the fundamental operations, which are of a high order, of the several classes requisite for the final detailed topographic map of the kingdom.

Its principal duties at present are—

(1) The field observations (scale 1:25,000) necessary and incident to the construction and publication of the topographic map of Spain, scale 1:50,000, in 1,080 sheets.

A general itinerary map of Spain is issued by the general staff of the army.

Italy conducts all its topographic operations through its military geographic institute, which has jurisdiction over all the operations (astronomic, trigonometric, topographic, and cartographic) necessary to such an object.

The principal works now being carried forward are—

(1) Field and office labors necessary and incident to the construction and publication of the new general topographic map of the kingdom, scale 1:100,000, in 277 sheets, which absorbs all others.

(2) Preparation and publication of the field minute plots at scales of 1 : 50,000 and 1 : 25,000.

(3) Special maps for war studies, scales 1 : 5,000 and 1 : 10,000, and of vicinities of Rome, Florence, etc., scales 1 : 10,000 and 1 : 25,000.

(4) General maps of the kingdom on various scales, and the constant and necessary revision of all maps issued by this bureau, other than the regular series, scales 1 : 100,000, 1 : 50,000, and 1 : 25,000. (See lists of maps.)

In Sweden the topographic bureau is charged with all the surveys required for military and economic purposes, with the fundamental initial base-measuring, trigonometric, topographic, leveling, and cartographic operations therefor.

At present the works carried on are—

(1) The field and office work necessary for and incident to the construction and publication of the main topographic map, scale 1 : 100,000, in 232 sheets (field-notes on scale 1 : 20,000 for southern and 1 : 50,000 for northern parts).

(2) The survey for construction and publication of the economic map of Sweden, scale 1 : 20,000.

(3) The topographic "Län" or county map for Sweden, scale 1 : 200,000.

(4) Topographic map of passes and positions, scales 1 : 10,000 and 1 : 20,000, and of Stockholm, scale 1 : 20,000.

(5) A general map of the kingdom, small scale, with revisions and changes required for all maps.

(6) Maps specially for war studies, in scales of 1 : 1,000 and 1 : 5,000.

The geographical service of Norway has charge of all the usual fundamental operations which such offices have been called upon to perform in Europe.

Its principal works at present are—

(1) All field and office work necessary for the principal topographic map of Norway, scale 1 : 100,000, in 54 sheets.

(2) The "Amt" map of Norway, scale 1 : 200,000, with large cities shown thereon at scales of 1 : 20,000.

(3) General map of Norway, scale 1 : 400,000, and the necessary revisions and changes for all maps.

Russia confides all its topographic work to the topographical section of the general staff, which includes all the preliminary main linear and angular measurements for fixing the initial geographic co-ordinates upon which the detailed topography is based.

The principal works now being prosecuted are—

(1) The field and office work necessary to the construction and publication of the great map of Russia in Europe, scale 1 : 126,000, in 792 sheets, which includes the topographic map of Poland, 59 sheets, same scale.

(Original field minutes of the above are taken at the scales of 1:21,000 and 1:42,000, and it is believed are published in specified instances, but not yet as a whole.)

(2) Topographic map of the Caucasus, scale 1:210,000, 77 sheets; topographic map of European Russia, scale 1:420,000, 154 sheets; topographic map of Asiatic Turkey, scale 1:840,000; topographic map of military districts in Turkestan, scale 1:1,680,000; topographic map of Western Siberia, scale 1:210,000; map of Central Asia, scale 1:4,200,000; and various others, with all the changes and revisions currently required.

Belgium carries on the astronomic, trigonometric, topographic, and cartographic works necessary for the resultant topographic map through its Military Cartographic Institute.

Its principal works at present are—

(1) Field and office operations necessary for construction of the topographic map of Belgium, scale 1:40,000, in 72 sheets. (Original field-minutes at scales 1:10,000 and 1:20,000.)

(2) The topographic map of Belgium, scale 1:20,000, in 450 sheets, now complete. (The publication of special plane-table sheets, scale 1:10,000, has also been begun.)

(3) Various older maps. (See lists of maps.)

(4) Current changes and revisions receive constant attention.

In Denmark all the topographic duties devolve upon the single organization constituted for that purpose.

The main works at present are—

(1) The topographic map of Jutland, scale 1:40,000, in 131 sheets.

(2) The same for the islands, scale 1:80,000, in 29 sheets.

(3) The field-minute sheets (construction and publication), scale 1:20,000—681 sheets for Jutland and 437 sheets for the islands.

(4) Topographic map of Zealand, scale 1:160,000.

(5) The constant correction and revision of maps.

Portugal carries on under one direction the following principal works on a trigonometric basis:

(1) The principal topographic map of Portugal, scale 1:100,000, in 37 sheets.

(2) Chorographic maps of Portugal, scales 1:500,000 and 1:1,000,000; also maps of Lisbon, scales 1:8,000 and 1:10,000, with all needed revision work.

The surveys of India (topographic and revenue) are carried on under one direction, with principal work in progress as follows:

(1) Field and office work necessary to the completion of the main topographic atlas of India, scale 1:255,561, in 177 sheets.

(2) Plans of towns, military stations, forts, etc., scales 1:500, 1:2,640, etc.

(3) Surveys of estates, military districts, presidencies, provinces, frontiers, etc., scales 1 : 3,168 to 1 : 2,027,520.

(4) Revenue surveys at scale of 1 : 15,840.

(5) Various general charts on inconsiderable scales, together with all correction and revision work.

There never having been defined by law a general topographic survey of the United States, all such works have but followed the specific money grants therefor. As has been stated, appropriations for the geographical surveys of the War Department have been dropped from the annual acts, and that Department for the time being but compiles and issues the best maps it is practicable to prepare with scanty funds. The Coast Survey continues as heretofore its narrow shore strip of topography of the land that first meets the eye of the navigator and establishes a central geodetic belt, while the survey of the Mississippi River Commission adds also its quota of topography. The Geological Survey is also producing such restricted topography upon which to base its general geologic map as the geologist requires.

PROGRESS.

The summary tables herewith afford a résumé of the progress in the several countries conducting systematic topographic works:

Summary table of data concerning the general govern

Number.	Name of country.	Area in square miles.	Total population.	Population per square mile.	In year.	Scales.	Number of sheets.	Area of each sheet in square miles.	When begun.	When to be ended.
1	Great Britain and Ireland (United Kingdom).	122,185	35,246,562	288	1881	1: 63,360	*696	216	1791..........	About 1890..
2	Germany	208,680	45,194,172	217	1880	1:100,000	674	370	1870..........	1900. .. ....
3	Austria-Hungary§.	241,553	37,889,954	157	1880	1: 75,000	720	391	1872..........	1886..........
4	France, including Algeria.	205,976 166,023	37,672,048 3,310,412	183 20	1881 1881	1: 50,000 1: 50,000	1,092 327	346	1880..........	In progress.
5	Switzerland........	15,978	2,846,102	178	1880	1:100,000	25	1,291	1832..........	1864.... ....
6	Holland............	13,740	4,322,647	315	1880-'81	1: 50,000	62	404.5	Prior to 1850.	1864..........
7	Spain..............	193,288	16,902,621	87	1883	1: 50,000	1,080	291	1870..........	In progress.
8	Italy..............	111,405	28,459,451	255	1881	1:100,000	277	625	1862..........	1892..........
9	Sweden............	172,967	4,603,595	26	1883	1:100,000	232	1,008	1812..........	In progress
10	Russia, including Poland.	2,130,201	82,900,045	39	1882	1:126,000	‖973	1,604	1827..........	In progress.
11	Belgium	11,373	5,655,197	497	1883	1: 40,000	72	243	1844..........	Complete...
12	Denmark (Jutland, including Bornholm Island). Denmark (Islands).	14,788	1,969,039	133	1880	1: 40,000 1: 80,000	131 29	106 294.5	1830..........	In progress.
13	Norway	125,046	1,806,900	14	1875	1:100,000	54	690	1828..........	In progress.
14	Portugal..........	34,418	4,708,178	136	1881	1:100,000	37	1,550	1852..........	In progress.
15	India	1,457,244	252,541,210	173	1881	1:253,440	177	4,094	1800..........	In progress

NOTE.—The following are the authorities for the areas adopted: "Superficies de l'Europe" for Austria, France, Switzerland, Holland, Portugal, Norway, Belgium, Russia, Spain, Italy, and Sweden; the "Ordnance Survey" for Great Britain; the "Landes Aufnahme," or Great General Staff Survey at Berlin, for Germany and its subdivisions, and the Gotha Almanac for 1883 for Algeria, Denmark, and India. The populations are taken from the Gotha Almanac for 1883.

* England and Wales, 360; Scotland, 131; and Ireland, 205 sheets.

ment topographic surveys in Europe and of India.

Present annual cost.	Administration.	Title of survey.	Remarks.
†1,433,640.66	War department until 1870, now office of works (organization unchanged).	Ordnance Survey (Southampton, England).	First base-line measured 1874. Published with hills in hachures without contours, also in outline with contours (all in black); "new series" 216 square miles represents the area of a sheet for England. 113 sheets (England and Wales), 34 (Scotland), and 203 (Ireland) issued to December 31, 1884. 90 sheets issued of old series (110 in all) for England.
‡242,256.00	War	"Landes Aufnahme," General Staff Topographic Bureau (Berlin).	395 sheets issued by Prussia, 6 by Bavaria, and 16 by Saxony; 417 in all to July 1, 1885. Of the 674 sheets Prussia furnishes 554, Saxony 30, Bavaria 60, and Wurtemberg 20; copper engraved in hachures.
319,200.00	War	"K. K. Militar Geografisches Institut." Military Geographical Institute (Vienna).	570 sheets issued in 1885. Published by heliogravure in hachures. The annual cost of cadastral survey of Bosnia and Herzegovina is, approximately, $170,670.
136,960.00	War	"Dépôt de la Guerre." "Service Géographique de l'Armée." Military Geographical Service (Paris).	90 sheets issued for France in 1885; zincographed in six colors. 23 sheets for Algeria in 1885.
25,000.00	War	"Bureau Topographique Fédéral." Federal Topographic Bureau (Berne).	Publication complete; copper engraved; hachures; heights in meters. (Dufour map.) This sum ($25,000) covers all cost of this bureau (field and office).
27,500.00	War	"Institut Topographique." Topographical Institute (The Hague).	Publication complete (the expense is for office work and field work necessary for new detailed map). Lithographed; hachures. (General topographic map of Java and Madura, in hachures and colors; scale 1:100,000; printed at military topographic department at The Hague, as also other "residences," as fast as surveyed.
474,570.00	Public works	"Instituto Geográfico y Estadistico." Geographical and Statistical Institute (Madrid).	The amount includes statistical work. 30 sheets issued in 1886; stone engraved; in five colors, with 20-m. contours.
78,604.00	War	"Instituto Geográfico Militare." Military Geographic Institute (Florence).	100 sheets issued in 1885; heliographed. This map absorbs all others; in hachures and contours.
25,000.00	War	General Staff Topographic Bureau (Stockholm).	64 sheets issued in 1882; copper engraved in hachures. Populous districts issued on scale 1:50,000.
....	War	"Section Topographique d'l'État-Major." Topographical Section of the General Staff (St. Petersburg).	505 sheets issued in 1876, showing railways. Hachures. A copper engraved military topographic map of Poland, now complete, was commenced in 1875; scale 1:126,000.
28,200.00	War	"Institut Cartographique Militaire." Military Cartographic Institute (Brussels).	72 sheets issued to 1885; engraved on stone; contours 5-m. interval; reduced by photography from scale 1:20,000; printed in black.
....	War	"Generalstabens Topografiske Afdeling." General Staff, Topographic Bureau (Copenhagen).	60 sheets issued at scale 1:40,000 in 1885, and 30 sheets issued at scale 1:80,000, 1882; contours 10 Danish "fod" apart. Reduced by photography from original plats, scale 1:20,000; copper engraved.
23,900.00	War	"Norges Geografiske Opmaaling." Norwegian Geographical Institute (Christiania).	This sum is for 1875–76. 48 quarter sheets issued to January 1, 1885; printed in colors; contours at intervals of 100 "fod" (31.38 meters).
....	Public works	"Trabalhos Geodesicos." Geographical Institute (Lisbon).	22 sheets published in 1885; printed in black; hachures.
573,715.00	Revenue and agriculture.	Survey of India (Calcutta)	67 sheets finished in 1885 also 152 quarter sheets; hachures. The great atlas of India. Royal military engineers, other army officers, and civilians. Reduced from surveys of different scales.

† Total estimates for year ending March 31, 1886. Appropriated for the year previous $1,257,509.25, expended principally for cadastral survey. £1 taken at $4.85.

‡ For year 1885.

§ The extension of this survey over Bosnia and Herzegovina is in progress. The only part of Europe not undergoing topographic survey is the Turkish Empire as it was formerly, and Luxembourg.

‖ Approximate.

Summary table relating to special gov

Number.	Name of country.	Area in square miles.	Total population.	Population per square mile.	In year.	Scales.	Number of sheets.	Area of each sheet (square miles).	When begun.
1	Great Britain	122, 185	35, 246, 562	288	1881	1 : 10, 560	*13, 391	24	1841
2	Prussia	136, 947	27, 412, 115	200	1880	1 : 25, 000	3, 688	50	1870
3	Saxony	5, 787	2, 970, 220	512	1880	1 : 25, 000	156	50	1872
4	Bavaria	29, 283	5, 271, 516	176	1880	1 : 25, 000	900	50	1867
5	Wurtemberg	7, 528	1, 970, 132	261	1880	1 : 25, 000	182	8	1820
6	Baden	5, 823	1, 570, 189	269	1880	1 : 25, 000	170	56	1875
7	Switzerland	15, 978	2, 846, 102	178	1880	1 : 50, 000 1 : 25, 000	118 442	132 33	1868
8	Holland	12, 740	4, 023, 047	315	1880-'81	1 : 25, 000	776	24	1862-'63
9	Italy	111, 405	28, 459, 451	255	1881	1 : 50, 000 1 : 25, 000	282 1617	158 39	1862
10	Belgium	11, 373	5, 655, 197	487	1880	1 : 20, 000	430	30. 24	1844
11	Denmark, (1) Jutland (2) Islands	14, 780	1, 969, 039	133	1880	1 : 20, 000 1 : 20, 000	646 420	500 80	1870

* Approximate.

† Only so far as yet shown on index (incomplete).

ernment topographic surveys in Europe.

When to be ended.	Administration.	Title of survey.	Remarks.
About 1890..	War department until 1870, now office of works (organization unchanged).	Ordnance Survey (Southampton, England).	Called county maps. Published with contours; fortifications, etc., added for confidential uses of war department. There were 1,882 full and 1,861 quarter sheets (England and Wales), 2,096 (Scotland), and 1,907 (Ireland) issued to April 30, 1885.
1900..........	War	General Staff Topographic Bureau. "Landes Aufnahme" (Berlin).	601 published in 1885. To be reduced and included in map of German Empire; scale 1 : 100,000.
1896..........	War	"Generalstabs Topographisches Bureau." General Staff Topographical Bureau (Dresden).	136 sheets published to 1885. Contours 10 m. interval, forming part of map of German Empire; scale 1: 100,000.
In progress.	War	"Generalstabs Topographisches Bureau." General Staff Topographic Bureau (Munich).	Publication commenced in 1875. Photolithographed. 290 sheets published in 1885. Contours 10 m. interval. Forms part of German Empire map; scale 1: 100,000.
In progress.	Finance	"Statistisch-topographisches Bureau." Statistical Topographic Bureau (Stuttgart).	Estimated and appropriated, $125,530. No sheets yet issued. Chromolithographed. Contours 5 m. interval. Contributes to German Empire map; scale 1 : 100,000.
In progress.	Commerce	"Topographisches Bureau." Topographical Bureau (Carlsruhe).	197 sheets issued in 1885, printed in colors. Contributes towards new general map of Germany; scale 1 : 100,000, in 674 sheets. Contours.
In progress	War	"Bureau Topographique Fédéral." Federal Military Topographic Bureau (Berne).	95 sheets issued, scale 1 : 50,000; 355 sheets issued, scale 1 : 25,000, in 1885. Chromolithographed in three colors; cultivated in bister; water, blue; balance black; scale 1 : 50,000 for Alps and foothills, with contours at 30 meters and hachures near summits; elsewhere scale 1 : 25,000 (copper engraved), with contours 10 m. and hachures about summits.
1882-'83......	War	"Institut Topographique." Military Topographic Institute (The Hague).	Engraved on stone and printed in colors. Confidential military map. Not for sale.
1892..........	War	"Istituto Geografico Militare." Military Geographical Institute (Florence).	There were 456 sheets, scale 1 : 50,000, and 437 at scale 1 : 25,000, issued in 1885. In hachures and contours.
Complete	War	"Institut Cartographique Militaire." Military Cartographic Institute (Brussels).	Publication complete in black, ended 1880. Photolithographed; one meter contours. Published in black, also in black and three colors. Principal roads and localities, red; forest and meadows, green; cultivation, yellow.
In progress.	War	"Generalstabens Topografiske Afdeling." General Staff Topographic Bureau (Copenhagen).	(1) 300 sheets issued to 1883; (2) 80 sheets issued to 1883. Direct reproduction by photolithography from plane table sheets.

COST.

While an average cost per square mile of a topographic or other survey does not convey an absolutely accurate idea of intrinsic merit, yet as an approximate guide to governments prosecuting or about to prosecute such surveys over large areas, estimates of cost, upon the various scales, based upon actual expenditures, can not but be of value.

In most instances these are naturally difficult to obtain. First, because apparently the executive branches carrying on the works have not, as a rule, been called upon to compile the data; again, since in any one of these undertakings from which has resulted a final, complete, and connected detailed topographic map of an entire state, the scale upon which the field minutes have been taken has often varied during the prosecution, as well as that of the published map. Of far more importance, however, is the variation due to configuration of ground and facility and means of communication over it.

The official reports of the survey of India give certain details from actual expenditures concerning cost, as follows:

1. For the general topographic survey (scale 1 inch to 1 mile) based upon the primary triangulation, an average (for 10 years) of approximately $11 per square mile.
2. For the village survey (scale 4 inches to 1 mile) based on main triangulation, an average (for 10 years) of $26.50 per square mile.
3. The cadastral survey (scale 16 inches to 1 mile), the average rate of $82 (approximately) per square mile, for a period of 15 years.

To obtain the total cost in any of the above cases, to each must be added the cost of the astronomic and principal triangulation work and that of leveling. The cost of the latter along main lines has been estimated at $35 per linear mile.

The actual total cost of the ordnance survey of England from its first organization to December 31, 1881, as given by the officer in charge of accounts, was £4,544,050 (estimating only for the years 1871 and 1872), or $22,725,250. The average cost per square mile to that date would have then been $186.

On the assumption that the cadastral survey can be completed in 1890, and allowing the present annual cost up to that date, the then cost per square mile would be $244.

The result will then be a map on the scale of 1 : 2,500 for all England, the same for the cultivated parts of Scotland and the 6-inch scale for the uncultivated portions, and the latter scale for Ireland entire.

The above cost is independent of the regimental pay of officers and enlisted men, which has been estimated would cause an increase of about one-eighth. The average cost of the present plane-table survey of the German Empire (scale 1 : 25,000), as given at the Berlin office (by an officer deputed for that purpose), assuming 200 German square miles as the annual amount, at a cost of 1,200,000 marks for field and office work, gives (approximately) $79 per square English statute mile. This sum is in addition to the cost of the earlier surveys, mostly on the 1 : 50,000 scale, for the separate German states. The estimated cost of field and office work by the Geographical Institute of Vienna (field plot 1 : 25,000) has been estimated at about 1,000 florins, a pretty large sum, reaching, approximately, $400 per square mile. The extremely detailed survey of the city of Bombay for municipal purposes of an area of 22 square miles and 149 acres on the scale of 1 inch to 100 feet for the city proper and 1 inch to 40 feet for the suburbs, was found to cost at an average approximate rate of $7,040 per square mile.

All the above estimates are based on actual expenditures, and do not include the cost of the production of the printed map from the original drawing.

Reference to details of cost may be found in House Ex. Doc. No. 270, 48th Congress, second session, under the headings of the several countries reported upon.

The following amounts appropriated for the purposes below, stated to the close of the fiscal year ending June 30, 1888, have been taken from the Statutes at Large:

Interior Department:	
Subdivision surveys of public lands (1802–1887)	$25,795,195.00
Surveys for State and Territorial boundaries (1802–1885)	517,846.59
Surveys of Indian reservations, including allotted lands (1789–1887)	1,914,913.16
War Department:	
Surveys for military defenses (1823–1875)	2,144,967.17
Military and geographical surveys west of Mississippi (1841–1880)	342,510.56

Pacific Railroad surveys (1853–1856)	$389,200.00
Geographical surveys west of 100th meridian (1872–1879)*	340,000.00
Examinations and surveys (roads and canals) (1811–1864)	855,435.57
Examinations and surveys (rivers and harbors) (1819–1886)	2,549,574.05
Survey of the northern lakes (1841–1885)	2,951,379.00
Survey by Mississippi River Commission (since 1879)	775,000.00
Treasury Department:	
Coast and Geodetic Survey (1806–1818, 1832–1887)	21,038,810.38
Interior Department:	
Geological and mineralogical examinations (mostly west of Mississippi) (1834–1852)	337,388.85
Geological and mineralogical examinations of the Territories (1867–1879)	713,825.00
Geological and mineralogical examinations of the Rocky Mountain region (1870–1879)	279,000.00
Geological exploration of the Black Hills (1876–1878)	26,588.62
Geological Survey (1879–1887)	3,038,840.00
State and Interior Departments:	
Surveys of international boundaries (1798–1885)	2,993,689.20
Navy Department:	
Exterior exploring expeditions (1836–1875)	1,351,708.86
Isthmian surveys (1857–1872)	126,500.00
Interior Department:	
Collections in Smithsonian Institution and National Museum (1856–1887)	1,621,891.42
Ethnology (1879–1887)	300,000.00
Various:	
Miscellaneous (1818–1885)	338,331.60
Total	70,755,095.12

RECAPITULATION.

Appropriations to June 30, 1888.

Public lands, including boundaries of States and Territories and Indian reservations	$28,227,954.84
Geographical and topographical (west of the Mississippi River, including Pacific Railroad surveys)	1,473,677.73
Examinations and surveys (roads and canals, rivers and harbors), lake survey, Mississippi River Commission surveys, including incidental repairs, contingencies, etc	7,131,388.62

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* This does not include $30,000 appropriated ($20,000 in 1875 and $10,000 in 1876) for illustrations and publications. The sums in this table are independent of these latter items of cost, including all field expenses and the preparation of office results, as manuscript text, maps, plates, etc.

Hydrographic or marine (Coast Survey)*	$21, 038, 810. 38
Geological examinations (mostly west of the Mississippi River, and all prior to present Geological Survey)	1, 750, 813. 47
Geological Survey (present organization) †	3, 036, 840. 00
International boundaries	2, 903, 689. 20
Surveys for military defenses (fortifications, field works, geological exploration fortieth parallel, etc)	1, 348, 989. 00
Exterior exploring expeditions	1, 351, 708. 86
Smithsonian and National Museum collections (including ethnology)	1, 921, 891. 42
Miscellaneous (including isthmian surveys)	477, 331. 60
Total	70, 755, 005. 12

The above appropriations, arranged according to Departments charged with the present control of the work, are as follows:

Interior Department (public lands, surveys of State and Territorial boundaries, geologic and mineralogic examinations, Smithsonian and National Museum collections, ethnology, etc.	$35, 647, 947. 99
Treasury Department (Coast Survey)	21, 168, 310. 38
War Department (military defenses, roads and canals, rivers and harbors, northern lakes, military and geographical surveys west of the Mississippi, Pacific railroads, geographical survey west of 100th meridian, Mississippi River Commission)	10, 549, 307. 95
State Department (international boundaries)	1, 911, 229. 94
Navy Department (exterior exploring expeditions)	1, 478, 208. 86
Total	70, 755, 005. 12

The above total sum uniformly expended throughout the United States would have been at an approximate rate of $23.50 per square mile, and yet the great general topographic survey has not been even begun. The results so far have been of a specific character, the purposes and objects of this class of works as a great public measure not having yet been seriously considered.

The entire amount appropriated has not in all cases been fully expended, but it is safe to assume that the cost of the service of the public surveys in the United States to June 30, 1888, including the aid and supplies from more general appropriations, and excluding all costs of publication and reproduction of original manuscript, maps, and plates, will have exceeded seventy-five millions of dollars.

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* There have also been expended from the appropriations of the War and Navy Departments sums including pay, rations, per diem, etc., of officers and enlisted men, authorized and actually employed on this work. The Secretary of the Navy states in his annual report for 1882 actual expenditures of $260,870.63, $220,969.38, and $220,221.64 as the sums, respectively, for the years 1879, 1880, and 1881. The cost to the War Department is unknown.

† The Director estimates $200,000 as the current cost of engraving and printing for the fiscal year ending June 30, 1885, which is defrayed from appropriations for public printing. (See American Journal, 3d series, p. 102.)

HYDROGRAPHIC SURVEYS.

INTRODUCTION.

Hydrographic surveys of domestic and foreign coasts are carried on under naval administration in eighteen countries, shown in the following list:

While the administration is naval in all cases, the navy department itself is under the department of railways, post-offices, and telegraphs (with a civilian personnel) in Belgium. In Austria it forms a part of the war department. In Norway the war and navy administrations together form the department of defense. In Portugal the office is under the department of public works, wherein the topographic, geologic, and hydrographic surveys are all combined under a single head.

In the United States there is found a hydrographic service attached to the Coast and Geodetic Survey under the Treasury Department.

There is also a hydrographic office in the naval establishment, but its sphere is restricted in the main to office duties, reconnaissance of foreign coasts, and the publication of compiled maps, while the systematic hydrographic survey of the ocean and Gulf coasts of the United States has been carried on by what is known as the Coast and Geodetic Survey of the Treasury Department.[*] Herewith follows a tabulated list of government works of hydrographic surveys:

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[*] Certain meagre and incomplete data concerning Government marine surveys will be found on pp. 497–538, House Ex. Doc. No. 270, 49th Congress, second session. This has been availed of in preparing the summary herewith, as also further original information since gathered by Commander J. R. Bartlett, U. S. Hydrographer, by official correspondence with the several foreign offices, freely furnished, and to some extent used herein.

List of government hydrographic surveys.

Name of country.	Title of work.	Present Director or Superintendent (1885).	Administration.	Remarks.
(1) England	Hydrographic Office, Admiralty.	Capt. W. J. L. Wharton, R. N. Hydrographer.	Navy	See its Catalogue. Office at London.
(2) Germany	Hydrographic Office, Admiralty (Hydrographisches Amt der Admiralität).	Rear Admiral F. von Schleinitz, Director of the Hydrographic Department.	Navy	See its Catalogue. Forms a department of the Imper'al Admiralty. Office at Hamburg.
(3) Austria-Hungary.	Hydrographic Office (Hydrographisches Amt).	R. Müller, Director.....	Imperial War Department, Marine Section (K. K. Kriegs Marine).	See its Catalogue. Office at Pola.
(4) France.......	État Major-Général, Service Hydrographique.	M. Baquet de la Gyre, Hydrographic Engineer-in-chief.	Marine and Colonies.	See its Catalogue. Office at Paris.
(5) Holland	Hydrographic Bureau (Afdeeling Hydrographie).	Capt. Van den Broecke, Chief Hydrographer.	Navy (Ministèrie van Marine).	Office at The Hague.
(6) Dutch East Indies.	Hydrographic Office (Hydrographisches Bureau).	Lieut. A. C. J. Edeling, Chief Hydrographer.	Marine	Office at Batavia.........
(7) Spain	Hydrographic Office (Officina Hidrografica).	Capt. Luis Martinez de Arc, Director.	Navy	See its Catalogue. Office at Madrid.
(8) Italy	Hydrographic Office (Ufficio Idrografico).	Capt. G. B. Magnaghi, Director.	Navy (R. Ministero della Marina).	See its Catalogue. Office at Genoa.
(9) Sweden	Hydrographic Office (K. Sjökarteverket).	Captain of the Navy, Director.	Navy	See its Catalogue. Office at Stockholm.
(10) Russia	Hydrographic Department (Département Hydrographique).	Lieut. Gen. Th. Wesselago, Director.	Navy (Ministère de la Marine Impériale).	Office at St. Petersburg.
(11) Belgium	Hydrographic Department (Département Hydrographique).	Mr. Vandenpeereboom, Engineer-in-chief.	Marine Branch of Department of Railroads, etc. (Administration de la Marine).	Office at Brussels.
(12) Denmark	Hydrographic Office (Sekaart Archivet).	Commodore H. P. Rothe, R. D. N., Director-General.	Navy	Office at Copenhagen.
(13) Norway	Hydrographic Section of the Geographical Institute (Geografiske Opmaaling).	Hydrographer to the Admiralty, a selected naval officer.	Defense	The war and navy administrations are combined at Christiania. See Catalogue.
(14) Portugal	Hydrographic Section of Geodetic Works. (Direcção Geral dos Trabalhos Geodesicos. Secção Hydrographica).	Rear-Admiral F. M. P. de Silva.	Public Works (Travaux Publiques).	Office at Lisbon.
(15) India.......	Marine Survey Department.	Commander Alfred Carpenter, R. N.	Marine	Office at Calcutta (maps now produced through Admiralty, London).
(16) Brazil	Hydrographic Bureau (Repartição Hydrographica).	Dr. José Rodrigues de Leria Quarta.	Navy (Ministro da Marina).	Office at Rio Janeiro.
(17) Chili	Hydrographic Office (Officina Hidrografica).	Ignacio Garcia Tudela, Director.	Navy (Ministro da Marina).	Office at Santiago.

List of government hydrographic surveys—Continued.

Name of country.	Title of work.	Present Director or Superintendent (1885.)	Administration.	Remarks.
(18) Japan........	H. I. J. M.'s Hydrographic Office.	Rear-Admiral N. Yanagi, Hydrographer.	Navy	Office at Tokio.
(19) United States	Coast and Geodetic Survey	Mr. F. M. Thorne, Acting Superintendent.	Treasury	See its Catalogue. Office at Washington.
(20) United States	Hydrographic Office......	Commander J. R. Bartlett, U. S. Navy.	Navy	See its Catalogue. Office at Washington.

Information regarding the above table and other assistance touching hydrographic matters has been kindly furnished t the U. S. Hydrographic Office, Navy Department, especially by Commander Bartlett and Lieutenants Dyer and Emmerich.

HYDROGRAPHIC SURVEYS.

ORIGIN.

Germany.—The German hydrographic bureau was established in 1866, after the North German confederation.

Spain.—The hydrographic office of Spain was established in the sixteenth century. (See letter from Juan Romero.)

Italy.—The hydrographic office of the royal navy was founded by royal decree in the year 1874.

Denmark.—The central institution for hydrographic works in Denmark and its colonies (Søkaart Archivet) at Copenhagen was established in 1784.

The survey of the Danish waters was commenced in the seventeenth century, occasionally continued from and during the eighteenth, and has been continued without interruption, especially since 1825.

India.—Surveys along the coast of India by Europeans began about the year 1600, the sailors having preceded the land surveyors by something like two hundred years. In 1873 the government of India appointed a superintendent of marine surveys.

United States Coast Survey, Treasury Department.—This work was first appropriated for in 1806, and actually commenced in 1807.

Hydrographic Bureau, Navy Department.—Lieut. M. F. Maury, when in charge of the Naval Observatory and Chart Depot, began the collection of information, from logs of vessels, for the purpose of making charts to show the prevailing winds and currents, etc., and of the physical features of the ocean, including its meteorology, etc. The present Hydrographic Office was definitely established by act approved June 21, 1866.

ORGANIZATION.

GREAT BRITAIN.—The staff of the hydrographic office at the admiralty in London is composed of the following: Hydrographer,[*] assistant hydrographer (both naval captains), eleven assistants (staff captains, staff commanders, and lieutenants),[†] four civilian assistants (admiralty clerks), seven draughtsmen; also clerks and copyists.

There is no distinct class of surveying officers; they are appointed for service at the admiralty for five years, and may be, and as a rule are, re-appointed but occasionally again go to sea, and retain only their line of promotion on the regular list.

GERMANY.—A detailed naval officer (rear-admiral or captain) is "chief" of the hydrographic office; two naval officers (captain or lieutenant-commander) in charge of divisions; one naval officer, chief of sections; four officials, chiefs of sections; also the necessary number of secretaries, clerks, assistants, and draughtsmen.

An official is director of the observatory at Wilhelmshafen, with three specialists as assistants.

An official chief of the chronometer observatory at Kiel.

A naval officer at the head of the depots of charts and instruments in Kiel and Wilhelmshafen.

Also the directors of surveys in the Baltic and North Seas.

Neither the officers engaged in the work of surveying nor those belonging to the hydrographic office form a special corps, there being no marine staff, but are detailed for these duties from the regular corps of naval officers for an indefinite period, which is usually a long one; and each line-officer is required to be qualified and prepared for duty in navigating and surveying. Line officers of the navy perform the navigating and surveying duties.

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[*] In the military branch of the British navy staff captains and commanders rank below captains and commanders, respectively.

[†] F. J. O. Evans, hydrographer, in 1882 was a staff captain on the retired list. Staff captains and commanders on board ship are subject to the authority of the executive officer, though he be only a lieutenant, but may succeed to the command in the absence of the captain. The old corps of navigating officers, composed of the grades of staff captains and commanders and navigating lieutenants, is gradually being consolidated with the regular line of the British navy. There are sixty-two officers employed on surveying duty, among whom are ten staff commanders and five navigating lieutenants. Regular line-officers are employed in eight of the nine vessels engaged exclusively in surveying, while the officers of the ninth are from the old navigating class, now merged with the line.

The name of the office is the hydrographic bureau (hydrographisches Amt) of the admiralty.

The whole organization of the German admiralty is essentially military, and is assimilated as much as possible to that of the army.

AUSTRIA-HUNGARY.—The following is the personnel of the Austrian hydrographic office at Pola: One director; four chiefs of divisions; two lieutenants of the line (observatory and depot of charts); one assistant in marine library; one marine commissariat assistant, appointed from the retired list; one foreman as mechanician, instrument department; six naval employés as manipulators; three civilian workmen, instrument depot; one messenger; also usually a detail of five officers of the navy; also a temporary detail of naval officers for certain works of a scientific or maritime military nature.

The director and heads of divisions of the hydrographic office are appointed by His Majesty the Emperor, upon the recommendation of the imperial war department, marine section.

The director of the hydrographic office is a captain or official of the sixth grade, but the heads of the four divisions are chosen either from the commanders or lieutenant-commanders on the active list of the navy, or are officials of the hydrographic office of the seventh grade.

FRANCE.—This office has lately been attached to the office of the minister of marine. It is in charge of the hydrographic engineer-in-chief, under the orders of the chief of staff. The personnel consists of the corps of hydrographic engineers, seventeen in number; a number of officers of the navy, one of which (an officer of superior rank) is chief of the division of nautical publications, another is in charge of the division of meteorology, and another in charge of the instruments for purposes of navigation; a managing agent, storekeeper, clerks, and draughtsmen.

The hydrographic surveys, as far as possible, are conducted by the hydrographic engineers.

Officers of the navy are also called upon to perform similar surveys.

A captain of the navy, assisted by several lieutenants, has charge of the preparation and publication of nautical books.

The position of hydrographer is a permanent one. He comes from the Polytechnic School, and his rank is between captain and rear-admiral.

The hydrographic engineers come from the Polytechnic School. Members must come from the Polytechnic School, ranking first with second lieutenants, then successively with lieutenants, commanders, captains, and commodores.

HOLLAND.—The hydrographic bureau of the ministry of marine consists of one chief of bureau, three naval officers, two surveyors and one for administrative work, two civilians for other administrative work, and two engravers.

There is no special navigating or surveying class in the Dutch navy.

SPAIN.—The chief of the hydrographic office, or chief of hydrography, is now a captain, who is relieved every four years by an officer of even grade, at the pleasure of the government. He is assisted by another officer of the rank of commander.

There are fourteen other officers, as follows: Five compilers and translators, six draughtsmen, a librarian, a photographer, and a storekeeper. There are six others, permanent engravers.

The chiefs and officers are selected unreservedly from the general naval service.

ITALY.—The hydrographic office is composed of one director (from captain to rear-admiral), four naval lieutenants in charge of different sections, a commissary of the royal navy (disbursing officer), five chief helmsmen, two under helmsmen, and twelve seamen.

In addition to the above military personnel the office employs the following civilian assistants: A chief draughtsman, six draughtsmen, a chief engraver, six engravers, one chronometrician, a chief of the mechanical workshops, six mechanical workmen, a chalcographer, a register, two carpenters, two men from the invalidi, and a porter. Occasionally other officers are added in excess of the complement, for special work and for acquaintance with the instruments and methods of survey.

There is no special surveying corps, but any officer of the navy can be called on to do hydrographic surveying.

Sweden.—The personnel of the hydrographic office consists of one chief and a number of officers of the navy and employés. The actual number is four officers and a draughtsman for the survey proper. Sometimes an additional number of officers are detailed. There are also attached to the office three engravers and two plate-printers.

The office is wholly naval, the men for surveying work coming from the general-duty offices of the line.

Russia.—The hydrographic department in Russia has Lieut. Gen. Th. Wespelago as its director.

Belgium.—The personnel of the hydrographic service of Belgium is as follows: One engineer-in chief, two engineers, one clerk, a draughtsman, one clerk, a copyist. The position of the engineer-in-chief, the engineers, and the clerks is permanent.

The professional staff is recruited from the candidates who have diplomas as engineers, or have served in the engineer corps of the army.

Denmark.—The hydrographic office is composed of one hydrographer (not permanent), four commanders, and a certain number of lieutenants and sub-lieutenants, all naval officers in active service.

The navy having no special corps of surveyors or hydrographers, it is intended to reorganize the hydrographic office of Denmark to make it embrace some of the different branches of nautical science.

Norway.—The hydrographic survey is immediately in charge of a selected naval officer.

Portugal.—The third section of the general direction of geodetic works is devoted to hydrography. The hydrographic engineers are naval officers who have taken a special course in hydrography.

India.—The duties of the hydrographic office are discharged by the superintendent, two deputy superintendents, nine assistants, three executive officers, one medical officer, a naturalist, and one superintendent of drawing branch.

Brazil.—The hydrographic office is under Dr. Jose Rodrigues as chief hydrographer.

JAPAN.—The hydrographic office is in charge of Rear-Admiral N. Yanagi, hydrographer. There are five divisions, namely, of surveying, the publishing and instrument division, the naval observatory, and the pay and account division.

UNITED STATES, COAST SURVEY.—The personnel (1884–'85) consisted of sixty-three field and one hundred and fourteen office civilian assistants, fifty-eight naval officers, and three hundred and forty seamen, or five hundred and seventy-five in all. (See p 525, Venice Report.)

Hydrographic Bureau.—The office is in charge of Commander J. R. Bartlett,* U. S. N., assisted by twenty-two lieutenants and five ensigns; ten lieutenants and one ensign of this number are on duty at the principal offices in Boston, New York, Philadelphia, Baltimore, New Orleans, and San Francisco. There are forty office employés, such as clerks, draughtsmen, printers, and laborers.

ADMINISTRATION.

In all foreign countries the administration of hydrographic surveys of coasts, etc., is naval, with the exceptions of Portugal, where this duty, supervised and directed by naval officers, is a branch of the public works department, and Belgium, which, without a navy department, places this administration in a civil department.

In the United States the Coast and Geodetic Survey is found under the Treasury Department, and the Hydrographic Office, with its labors confined to the survey of foreign coasts, is a branch of the Bureau of Navigation of the Navy Department.

FUNCTIONS.

GREAT BRITAIN.—The jurisdiction of this service covers home, colonial, and foreign coasts. The functions are various and numerous. The most important are to execute accurate surveys of all parts of the world which are visited by British ships, and to prepare and publish these surveys in the form of charts; to write and publish nautical directions to accompany the charts; to compute, prepare, and publish tide-tables and light-lists for all parts of the world; to receive and take charge of all remark-books from the captains and navigating officers of Her Majesty's ships, as well as information from all other sources, home or foreign; to compile such information and publish it promptly in the form of hydrographic notices or warnings of danger, in order that all charts and other nautical documents may be kept corrected up to the latest period. The admiralty charts, numbering about 2,900, may be classed under five heads, viz, ocean, general, and coast charts, harbor plans, and physical charts.

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*This officer has since been succeeded by Lieut. G. L. Dyer, U. S. Navy.

GERMANY.—The duties of the hydrographic bureau are mentioned on page 503, Venice Report.

One of the most important works of the admiralty is to provide charts of the east coast of Russia, those in existence being in Russian, and hence of no use to German sailors.

AUSTRIA-HUNGARY.—The functions of the hydrographic office are referred to on page 504, Venice Report.

FRANCE.—The entire work relating to hydrography and the correction and printing of charts is done by and through the hydrographic office at Paris. The publications (instructions, reports, and maps) are numerous. The jurisdiction of the hydrographic bureau extends over home and foreign coasts, and its duties, as in case of all foreign hydrographic offices, relate to both field and office work, of surveying, and to the preparation and publication of maps, charts, reports, treatises, notices, lists, etc.

The operations of the hydrographic surveys extend to the limits of tide-water, or, where there is no tide, to the head of navigation.

HOLLAND.—The jurisdiction of the hydrographic coast work of Holland, projected purely in the interest of navigation, is confined to the home coasts, there being a separate office for the survey of the East India coasts at Batavia, where Dutch surveying vessels are actively engaged in the marine surveying of their possessions in the East Indian Archipelago. Its labors are confined to soundings and observations at the mouths of rivers and harbors, and along the coast to the head of tide-water navigation, the main survey of which has long since been completed. All the charts of the coast and harbors are engraved and printed at the admiralty.

SPAIN.—The hydrographic office controls all that concerns the making of surveys by hydrographic parties at home or abroad.

The coast and hydrographic surveys are united and belong to one party. The published works of this office, as is usual, appear and may be found in the printed catalogue thereof.

ITALY.—The duty of making the surveys of the coasts of the kingdom is the exclusive function of the hydrographic bureau. This office provides all the ships of the royal navy with the hydrographic data and charts, and the nautical and geodetic instruments with which they should be furnished, according to their missions. The work ashore and afloat is done by the officers serving on the hydrographic vessel, co-operating, where possible, with the royal military geographic institute of the royal army. (See also p. 517, Venice Report.)

SWEDEN.—The duties of the hydrographic office are as follows: Hydrographic surveys of the coast and lakes open to navigation, soundings and general exploration of the waters surrounding the country, and coast defenses, magnetic observations, etc.; also the publication of charts and descriptions of coast channels, etc.

The projection of the hydrographic charts is the same as that employed for the general staff's military topographic maps.

RUSSIA.—The hydrographic department uses the shore triangulation points of the military topographic land survey.

BELGIUM.—The duties of the hydrographic service are surveys of coasts, soundings, observations relative to the phenomena of tides, curvature of the earth's surface, the determination of ebb and flow of tidal currents, the velocity of currents at the surface and at different depths. These studies are completed by observations for temperature, density, and saltness of water, the latter at recurrent intervals, as also the publication of results.

DENMARK.—The hydrographic office has charge of the survey of home and foreign coasts, and consists independently of the survey proper, of nautico-meteorologic observations, and in publishing annually the results of all observations of tides, currents, degree of saltness of sea-water, etc.; has also the care of nautical instruments. There is a division for secret charts, which latter contain very detailed surveying, and are intended for time of war, when all sea-marks and light-ships are withdrawn.

PORTUGAL.—The duties of the hydrographic office are as follows, namely: Hydrographic reconnaissances; surveying and construction of general maps and hydrographic charts and plans of coasts, islands, bars, ports, and rivers; soundings; meteorologic, magnetic, astronomic, and geodetic observations; location of light-houses, buoys, etc. This office has published a series of coast and harbor charts from new surveys.

INDIA.—The office of marine surveys in India was established for the purpose of completing and maintaining the surveys of the Indian coast from the southern extremity of Tenasserim to the western limit of Sind, beyond which all surveys are performed by the British admiralty.

In October, 1875, the duties of this branch were defined as follows: "The systematic surveys of the coast of India are to be carried on with suitable vessels sufficiently equipped and manned. These surveys are to be connected with the shore surveys, and closed in on points already fixed by the British trigonometric survey." (See also p. 522, Venice Report.)

JAPAN.—The hydrographic office of the navy is charged with the marine surveying and publication of the charts, the compilation of the books relating to sailing directions, etc.; also the meteorologic observations, the issue of the publications as above, and the supply of the necessary instruments and other matters connected with the safety of navigation.

The naval observatory is in charge of the following: Heavenly meteorologic and magnetic observations; determination of longitude by telegraphic communication; to regulate and test the instruments and to issue necessary alarm; to make weather and current charts by examining the different observations along the coast; to prepare and arrange the reports and statistics connected with these observations and tests of instruments.

UNITED STATES.—The functions of the Coast and Geodetic Survey appear in sections 4681, 4682, 4683, and 4684 of the Revised Statutes, amended by various subsequent authorities contained in appropriation acts, and are substantially as follows: To make a survey of the coast, in which shall be designated the islands and shoals with roads or places of anchorage within twenty leagues of any part of the shores of the United States, and also the respective courses and distances between the principal capes or headlands, etc.; also examinations and observations with respect to St.

George's Bank, and to any other bank or shoal, and outward to the Gulf Stream.

The instructions for carrying out the acts of Congress are found in Treasury Department Circular No. 110. (See also p. 526, Venice Report.)

The acts of Congress upon which the work of the Coast Survey is founded define it as an aid to commerce and navigation, while the clause in the report of the board on reorganization in 1843 provides for the topography as far inland as needed for purposes of commerce or defense. The law itself is silent as to the uses of this work as an aid in the military defense of the country.

HYDROGRAPHIC OFFICE.—The functions of the Hydrographic Office are found in sections 431 and 432, Revised Statutes, which provide for the duties of this office; the improvement of the means for navigating safely the vessels of the Navy and mercantile marine by providing, under the authority of the Secretary of the Navy, accurate and cheap nautical charts, sailing directions, navigators' manuals of instruction for the use of all vessels of the United States, and for the benefit and use of navigators generally; for the preparation of maps, charts, and nautical books relating to and required in navigation.

It has no authority over any surveys of home coasts, but there may be assigned to it, in the discretion of the Secretary of the Navy, surveys being conducted by naval officers on foreign coasts.

APPENDIX F.

MEMOIR UPON THE VOYAGES, DISCOVERIES, EXPLORATIONS, AND SURVEYS TO AND AT THE WEST COAST OF NORTH AMERICA AND INTERIOR OF THE UNITED STATES WEST OF THE MISSISSIPPI RIVER, BETWEEN 1500 AND 1880, INCLUDING LATER BIBLIOGRAPHICAL AND OTHER REFERENCES TO DETERMINED LATITUDES, LONGITUDES, AND ALTITUDES AVAILABLE FOR THE BASIS OF THE PERMANENT OFFICIAL TOPOGRAPHIC ATLAS OF THE UNITED STATES.

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PART I.

GEOGRAPHICAL DISCOVERY AND EXPLORATION, WEST COAST AND INTERIOR, 1500 TO 1800.

This period of exploration is alluded to in a brief paragraph in Warren's Memoir, and was evidently considered of no particular importance as regards latitudes and longitudes from which to compile the map of the territory west of the Mississippi that was constructed after the completion of the Pacific railroad surveys. It is mentioned occasionally in the Coast Survey Reports,* while in that for 1884 appears an article, regarding the various explorations, by Dr. J. G. Kohl, whose complete manuscript fell into my hands through the courtesy of the geographical society of Bremen. It is doubtless true that there has been no permanent use of the latitudes and longitudes of these early explorers, but the Coast Survey have been assisted by them to some extent during their early reconnaissances, and indirectly, also, parties engaged in the interior. However, if the discoveries in the Western Ocean had not been made, there would have been no requirement for the early voyages of discovery and exploration, whether their geographic positions were the best or not.

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* See Coast Survey Report, 1857, Appendix No. 52.

The necessities of the time, whether dictated by war or conquest, commerce or defense, demanded information, exterior and interior, of the new found lands, and little by little the Indian rawhide and bark sketches and traditional itineraries gave place to the actual travels, investigations, reconnaissances, and finally instrumental surveys, until ultimately the Government expeditions, equipped with the best instruments in vogue at the time, carried their examinations more into detail, especially on the west coast and occasionally in the interior, until there resulted a series of sketches, maps, and charts, the outgrowth of these undertakings, descriptions of which were prepared with great fullness by the late Dr. J. G. Kohl, but which have scarcely been treated upon in the literature of the country.

He also gathered a large collection of maps (mostly copies) relating to this subject while an official of the State Department, within the archives of which these still remain. They have not been availed of, except that Mr. Justin Winsor has published in the Harvard University Bibliographical Contributions, No. 19, an annotated calendar for the use of scholars, entitled "The Kohl Collection of Early Maps," prior to which I had selected, somewhat at random, a number of the most intelligible specimens that were most easily found in the then condition of arrangement of the maps, of which reproductions are herewith found listed in the table of contents and described separately.

PRIOR TO 1500.

Geographical knowledge, confined to a learned few among the ancients, consisted, at the close of the fourth century, in a surmise only of the sphericity of the earth, with vague and diminutive conception of its size, while the positive knowledge of Europeans was limited to a parallelogram, north-west and south-east in direction, about 120 degrees east and west and 50 degrees north and south, being an area bordering on the Atlantic and Indian Oceans, including the Mediterranean, parts of southern, southwestern, and central Europe, Arabia, Persia, India, and northern Africa. There were various theories concerning the shape of southern Africa; a *mare oceanum*, stretching westward to unknown Asiatic shores, with hypothetical islands intervening, opinions that this sea was navigable, and that India might possibly be reached by sailing westward. The popular mind only grasped the idea of sphericity long after the first circumnavigation in the sixteenth century. From the fifth to the fifteenth century cosmographical and all other knowledge lay almost entirely dormant. It seems probable that the American continent may have several times been reached prior to the discoveries by Columbus, but the following appears to be the only authentic published information now extant:[*]

In 986, Biarne, sailing southwest from Iceland, came within sight of land, believed to have been America, and conjectured by Kohl to have been Cape Cod, Nova Scotia, and Newfoundland.

In 1000, Leif, son of Eric the Red, sailed southwest from Greenland in search of lands seen by Biarne, and made a settlement at some point on Narragansett Bay. Columbus made his first voyage in 1492,[†] but did not reach the main-land. Cabral reached the coast of Brazil in about latitude 10 degrees north in 1500, and was the first of the navigators of this period to reach the continent.[‡]

FROM 1500 TO 1800.

There were eleven nationalities engaged in the discovery and exploration of the west coast and interior of the United States between the years 1500 and 1800. The chronological statement that follows gives more than one hundred and fifty separate expeditions, endeavors, or attempts in this direction, and comprises all those of importance known to me. Of these several voyages and explorations seventy-six were Spanish, twenty-three English, twenty-one French, fifteen (at least) by the Jesuits and Franciscans, six Russian, four American, three German, two Italian, two Danish, one Portuguese, and one Hungarian.

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[*] See De Costa, B. F. The Pre-Columbian Discovery of America, Albany, 1868.

[†] It has not been proven that Prince Henry, Toscanelli, or Columbus had any knowledge of the discoveries by the Norsemen.

[‡] See Bancroft's History of Central America, vol. I, pp. 67 *et seq.*

The first voyage of Columbus gave to all Western Europe the earliest impulse for western voyages of discovery. The King of England, also rich merchants, among them Italians, became interested and favored the idea of finding a direct westerly route to China and Japan.

Hence, with the single exception of the Russians, who came from the west, all the early European discoverers and explorers of America set out from the east. They found the North American continent as a barrier, and sailed along its entire eastern coast. This coast was comparatively well known twenty years before the western or Pacific was discovered. The latter was discovered by Balboa, at the Isthmus of Panama, in 1513, and the Strait of Magellan by this navigator in 1519. Those who immediately followed these discoveries occupied themselves with the South American coast, hoping to find water communication between the Atlantic and Pacific, when subsequently, and for a similar purpose, Cortez and his captains in 1530 commenced to turn the direction of discovery from Central America to the northwest. During forty years (1492 to 1532) the east and west coasts of South America were explored and made known, as well as the east coast of North America as far north and beyond the St. Lawrence, and a portion of this river, while fully one-fourth of the two Americas, the west coast of North America, remained unknown. This led to many and varying speculations by cosmographers. Some thought there was no American continent but only a succession of islands, but the principal belief was that North America was a large peninsula joined to Asia, while Columbus died ignorant of having discovered a new continent.

Expeditions for discovery along the northwest coast expected the close proximity of Japan and China. After the Isthmus and Cape Horn were discovered, theoretically a supposed northwest passage promised shorter water communication to the above countries and possibly Cathay. Hence the expeditions along the east and west coast often took the form of a search for this passage.

In various relations, connected also with arctic explorations, these undertakings continued, until in October, 1850, Captain McClure, of the English navy, from Behring Strait reached the waters of "Winter Harbor," where Parry had come from the east in 1820, and whence he was relieved by Lieutenant Kellett's sledge party across the intervening ice space, thus proving a northwest water communication for North America, ice locked for a short distance only, yet unserviceable as a highway of commerce.

Cortez began the exploration of the west and northwest coast, which culminated in the discovery of Behring Strait by Behring.

The Spanish expeditions were dispatched principally by the government of New Spain, and were, as is true of nearly all the expeditions of this period (especially Spanish and English), based on the ideas of commerce and conquest.

The English expeditions of Cook, Colnet, Vancouver, and Broughton were ordered by government, but in the main the underlying impetus was commerce, except for the Jesuits and Franciscans, who went as missionaries to spread the faith.

The expeditions, then, were naval, military, civil, clerical, corporate, and individual. During these three centuries new countries were sought for, principally with the hope to find gold and spices, to found government, and aggrandize religion, while in these later days the religious zeal and love for gold have been replaced by the more peaceful ways of commerce and competition that are now making known the remaining portions of the globe available for civilization.

The "northern route to China" was a problem long cultivated, while the full discovery of America was mainly completed in modern times. In the sixteenth century explorations reached 43 degrees north latitude. From 1602 to the middle of the eighteenth century no Spanish expedition reached the cold and inhospitable northwest coast. Meanwhile the Jesuits and Franciscans "civilized" Upper and Lower California. The expeditions were substantially Spanish till the time of Drake (1579). These were quite continuous till Cabrillo (1542-'43), when little was done till Velasco (1564). The next considerable interval of quietude was from Iturbi (1615) to Ortega (1632), then Casañate (1648) to Pinadero (1664), after which, except for slight attempts ending in 1683 (Atondo), the Spanish were seen nowhere upon the coast till the expedition of Galvez (1767), about one hundred years later. For two centuries (1550–1750) nothing was done as compared with the activity from 1492 to 1550

The English expeditions (coastwise and interior) continued till 1842. Many expeditions under French auspices (1673–1750) sought for the "great river of the west" of La Hontan.

The Franciscans either accompanied exploring parties or made independent expeditions from Ruiz (1581) to Junipero Serra (1782), more than two hundred years.

The Jesuits joined expeditions as early as 1642, but commenced independent journeys under Salvatierra (1697), and continued with much activity until their expulsion (1767) from California.

The first Russian (Deschnew) explored the coast in 1648, and the last in 1841.

The French explored in the interior as early as 1639, and conducted important expeditions (1820–'42).

American explorers began with Kendrick (1788). The fur companies were active in exploration (1806–'21), as also the Russian settlements (1812–'41). Missionary travels on land were made from year to year.

Although Ulloa, in 1539, determined Lower California to be a peninsula, yet the fact was lost to view, and it was only in 1766 that Link determined and made known for all time the peninsularity.[*]

Cortez discovered Lower California, which Ulloa sailed around Upper California was first visited by Cabrillo (1540–'43) The interior was but imperfectly settled and explored toward the seventeenth century. It was not till the nineteenth century that this country was thoroughly explored by Americans.

From 1579 (Drake) to 1778 (Cook), (two hundred years,) except for the Russians, no one visited the northwest coast but the Spaniards.

During the thirty years closing the eighteenth century one expedition after another, combining traffic and exploration, almost yearly revealed all the mysteries of the West. Even trading voyagers wrote narratives, each one bringing new facts and names.

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[*] Lower California was first called an island by the Dutch pirates at the Bay of Tichilingue, on the southeast coast, at the beginning of the seventeenth century. Purchas, in 1625, was the first to print the above error.

Cabrillo's was the most remarkable in the sixteenth and Viscaino's in the seventeenth century of all the Spanish voyages. The latter made the first reliable astronomic observations and general rude reconnaissance of the coast, while Vancouver conducted what might be termed the first continuous reconnaissance. Good observations were also made by Cook, Gali, Perouse, and Malaspina. Mackenzie was the first to reach the northwest coast from the east. Vancouver's time was the most active in the history of west coast explorations, during which a total of thirty vessels took part, with officers of ability, and accompanied by astronomers. The Franciscans succeeded the Jesuits. Most of the French came from Canada. In 1640 some Cossacks sailed down the Amoor River to the Pacific. Deschnew reached Behring Strait along the north coast of Siberia. Kamchatka was discovered at the end of the seventeenth century. The Hudson Bay Company first explored the Yukon. The missions were the basis of settlement and assisted in establishing government.

The scientific and commercial world for a long time reaped no benefits from the Spanish expeditions, the records of which were retained by the court.

Prof. George Davidson makes comparison of the nomenclature used by Ulloa, Cabrillo, Ferello, and Viscaino, comparing it with that of to-day. (See Appendix 7, U. S. Coast and Geodetic Survey, 1886.)

The Kohl manuscript refers to this feature at great length in his hydrographic descriptions. It does not appear that the numerical latitudes and longitudes used by the several expeditions in plotting their routes have ever appeared in print. They doubtless rest principally in the old archives of "New Spain," in the City of Mexico, and at the hydrographic bureaus at Madrid and London, where nothing less than a scientific search will develop their existence and comparative value. However, as before stated, these have all been replaced by later determinations.

Want of time, delicate health, and various duties have prevented such a digest of the great mass of facts at disposal as would summarize all the leading events and results, and hence one must be content with the presentation of a chronological list, with remarks thereon, as an index, at least, to what took place during an interval of fully three centuries, trusting that the scientific as well as literary history of these endeavors will be fully treated hereafter.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS TO THE WEST COAST AND INTERIOR OF NORTH AMERICA BETWEEN 1500 AND 1800.*

(Including Columbus and Corte Réal.)

NOTE.—The following abbreviations have been used in list of authorities: (1) K. for Dr. J. G. Kohl; (2) M. for de Mofras; (3) B. for Burney; (4) G. for Greenhow; (5) T. for Twiss. For nationalities: (1) I. for Italian; (2) P. for Portuguese; (3) S. for Spanish; (4) F. for French; (5) E. for English; (6) Gr. for Greek; (7) R. for Russian; (8) G. for German; (9) D. for Danish; (10) H. for Hungarian; (11) A. for American; (12) Fr. for Franciscan.

No.	Name.	Nation.	Year	Authority.	Remarks.
1	Corte Réal	P	1500	G. B.	Belief in the fictitious "Straits of Anian" grew out of a supposed voyage by the brothers Corte Réal. No authority for this. Anian appeared about 1500 in Italy. (Harrisse.)
2	Columbus	I	1502	M	During fourth voyage attempted to find a strait leading to the South Sea and land of the spices. (Did not reach the main-land. Kohl, p. 514, U. S. C. S., 1884.)
3	(H) Nuñes de Balboa	S	1513	M	Discovered and established existence of the South Sea, from heights near Panama.
4	Tello de Guzman	S	1515	Dr. S. Ruge	The first to visit Panama.
5	Pineda	S	1519	K	Discovered Mississippi River and named it "Rio de Espiritu Santo."
6	Espinosa	S	1519	Ruge	Sails from Panama as far as the Gulf of Nicoya, in 10° north latitude. Visited in canoes in 1517 by Hurtado.
7	Cortes	S	1522-'24	M	Sent several expeditions to west coast of Mexico.
8	Gonzales de Avila	S	1522	Ruge	Discovers the west coast of Nicaragua. His pilot Niño went even as far as Chiapas.
9	Garay	S	1523	K	Discovered mouth of Rio Grande del Norte.
10	Guevara	S	1526	Bancroft	Via Straits of Magellan reached Tehuantepec and Zacatula.
11	Mendoza	S	1532	M	Continued the explorations of coast of New Spain. M. de Mofras and his researches are unknown to me. Of Hurtado de Mendoza I only know the expedition of 1532, undertaken by orders of Cortes. Mendoza was killed by the natives on the coast of Cinaloa. Before him Nuño de Guzman had discovered Jalisco and Cinaloa in 1530. (Professor Fischer.)
12	Narvaez	S	1528	Ruge and K.	Expedition to Florida. Narvaez dies. From his army four men, Cabeza de Vaca, Dorantes, Maldonado (Kohl says "Alonzo de Castillo"), and Estebancio, went by land, across the Mississippi River, through New Mexico and Arizona, to Culiacan, 1535. Kohl says 1536.
13	Maldonado	S	1528	G	Explored 100 leagues of west coast of Mexico.
14	Guzman	S	1530	Ruge	By land to the west coast of Mexico, to Sinaloa ("Nueva Galicia").

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* Copies of this list as at first compiled having been submitted to James Carson Brevoort, Rev. B. F. De Costa, D. D., Henry Harrisse, Professor Fischer, and Professor Ruge, and it has been revised in accordance with their suggestions, as found noted.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
15	Mendoza	S	1532	G. B. M. and K. (See also Herrera and Navarrete; sailed from Acapulco.)	Reached 27° north longitude at west coast of Mexico. This expedition is lost to view. Not known how far it went. (Bernal Diaz del Castillo, Lib. XII, p. 2. R.)
16	Grijalva	S	1533	Colecc. de doc. inedit., XIV, p. 128.	Discovers St. Thomas (St. Benedito. R.).
	Becerra	S	1533-'34	G., B., M., and K.	Sailed from Tehuantepec, Gulf of California. (See Gomara.) Ximenes, the pilot who murdered Becerra, discovered Lower California.
17	Cortes	S	1535-'37	G., B., M., and K.	Sailed from Chiametla. Takes possession in person of southeast part of Lower California. Gomara says it is not known how far up the Gulf of California Cortes sailed.
18	Cabeza de Vaca	S	1536	K.	From Mississippi River Valley, via what is now New Mexico, to northern Mexico. (Member of Narvaez expedition.)
19	De Soto	S	1538	K.	Explored a part of the lower Mississippi Valley. Was followed by Moscoso, who recognized the delta and afterward went into interior of Texas. Then for one hundred years the Spaniards did not add to the knowledge of this region.
20	Ulloa	S	1539-'40	B., G., T., M., and K.	From Acapulco. Reconnoiters both shores of Gulf of California. Subsequently visits Magdalena Bay and sails around Lower California. Went as far as Isla de los Cedros (28° 10' north), from whence he sent one ship back, proceeded further, and not heard from again. (R.) Latitude 30° north. (K.) (See also Ramusio and Hakluyt.)
21	Niza, Marcos de	Fr	1539	K., B., G., and Whipple.	From Culiacan penetrating northward found the seven cities of Cibola, alleged to have been discovered by Cabeza de Vaca.
22	Alarcon	S	1540	B., G., M., K., and Whipple.	Sails from Mexican coast. Adjunct to Coronado's expedition. Discovered Colorado River and ascended it 85 leagues.
23	Coronado	S	1540-'42	G., B., M., K., and Whipple.	Reached the seven cities of Cibola, the province of "Quivira," and northward to 40° north latitude.
24	Cabrillo	S	1542-'43	G., T., B., M., and K.	Sails from Navidad, Mex. Examined west coast of California, reaching approximately 42° north latitude. Discovered San Clemente, Santa Catalina, and St. Bernardo Islands, Santa Barbara channel, and bays of San Diego and Monterey. After Cabrillo's death (January 3, 1543), his pilot Ferrelo sails northward, presumably to 43° north. (R.) Cabrillo was a Portuguese in Spanish service. I do not believe that he passed Cape Mendocino. (See also Navarrete and Herrera.)
25	De Soto	S	1541	G., K	Discovered the Mississippi River near the mouth of the Arkansas. Sailed from Cuba, May 18, 1539, reaching Tampa.
26	Moscoso	S	1542-'43	K.	Explored about one hundred miles of lower Mississippi, recognized the delta, and explored along the coast of Texas. Succeeded De Soto.
27	Ocampo	S	1543	K.	Member of Coronado expedition. Passed from Quivira, through the region now known as Texas, and came to Panuco.
28	Olnos	S	1544	K.	From Panuco northward toward confines of Florida.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
29	Bazares	S	1558	K.	Coasted north from Panuco, probably as far as Matagorda Bay.
30	Velasco	S	1564	M	Made an expedition to the California coast.
31	Urdañeta	S	1565	G., B., and K.	Claimed by "one Salvatierra" to have made the northwest passage. Unauthentic. (B.) West from Philippine Islands to Mexico. (K.)
32	Ladrillero	S	1574	G., B., and K.	Pretended to have sailed through a passage near Newfoundland from Atlantic to Pacific.
33	Drake	E	1579	T., G., B., M., and K.	Sailed from England via Magellan Straits. Reached about the same latitude attained by Cabrillo. Claimed by many to have discovered San Francisco Bay. Named the California coast "New Albion." (See Fletcher: The world encompassed. An English freebooter.)
34	Ruys (spelled "Ruis" by Kohl.)	Fr	1581	K. and Whipple.	Travels north from the valley of San Bartolomeo, near the silver mines of Santa Barbara, at outskirts of Spanish settlements in Mexico; 160 leagues, reaching New Mexico.*
35	Gali	S	1582-'84	M., B., and K.	From Acapulco. Reconnoitered coast north of 37th parallel. Made no important discoveries. (Gali: Le Grand Routier de Mer. See also Hakluyt.)
36	Espejo	S	1582-'83	K. and Whipple.	Visits Pueblos on Rio Grande, also Zuñi. A principal discoverer in New Mexico.
37	Juan de Oñate	S	1591	K. and Davis, p. 267.	Explores and colonizes New Mexico, and founds Santa Fe in 1611. The Rio Grande, believed for a long time to head in Salt Lake, was laid down as entering the Gulf of California, until corrected by Coronelli on his map of approx., 1690. Results meager.†
38	Cavendish	E	1587	G. and K.	Touched at southern end of Lower California. An English freebooter.
39	De Fuca. (Unauthenticated. B.)	Gr	1592	G., T., B., M., and K.	Pretended to Michael Lock to have made the northwest passage.
40	Cermeñon	S	1595	M. and K.	From Mexican coast. Wrecked either in or near San Francisco Bay.
41	Viscaino	S	1595	B	Examines the lower part of the Gulf of California. (Doubtful.) Kohl gives only 1596.
42	Viscaino	S	1596	G., T., B., M., and K.	From Acapulco. Does not pass beyond lower entrance of the Gulf of California. Mentions Island of Santa Cruz.
43	Viscaino	S	1602-'03	G., T., B., M., and K. Coleccion de doc. inedit. rel. al desc., tom. VIII, p. 539. Madrid, 1867. Navarrette in colec. d. doc. ined. p. l. hist. d'España, xv, 45. (B.)	From Acapulco. Reaches Cape Blanco or approx. 43° north latitude. (B.) (Aguilar probably saw the mouth of the Columbia River.—K.) His companion, Aguilar, went as far as 43° north and to Cape Blanco. (B.) Did not visit the Gulf of California. Mentions Sierra de St. Lucia (Coast Range of California). Discovered Point Reyes. (See also Torquemada and Navarrete.)
44	Maldonado (fictitious)	S	1609	G., T., B., M., and K.	Presented *fictitious* account of voyage by the northwest passage.

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* The following entradas into New Mexico were made: Rodriguez, 1581-'82; Morlette in 1591, and Bonilla about 1596. (See Bancroft, Northwest Coast, vol. 1, p. 20.) Also Francisco Cano, 1568; Chamuscado, 1581; Martin, 1583; Castaño, 1590, and Humaña, 1596. (See Narr. and Crit. Hist., vol. II, p. 504.)

† Texas was entered by Perez and Lopez, 1654, and Captain Vaca, 1534. (See Bancroft, Northwest Coast, vol. 1.)

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued

No.	Name.	Nation.	Year.	Authority.	Remarks.
45	Iturbi	S	1615	M. and K.	Made reconnaissance along east coast of Gulf of California to approx. 30° north latitude. Did not reach the mouth of the Colorado. History written by Father Andres Perez de Ribas, a Jesuit.
46	Ortega	S	1632	M. and K.	Made three visits to the southerly parts of the Gulf of California lying between Cape St. Lucas and the Bay of La Paz, from whence pearls were brought.
47	Carbonell	S	1636	M. and K.	Made visit for pearls to Gulf of California. Did not reach the mouth of the Colorado.
48	Nicolet	F	1639	K.	Believed to have been on the waters of the Wisconsin.
49	Cañas, Cestinde	S	1642	K.	Sailed from near Bay of La Paz with soldiers and missionaries, 60 leagues to the northwest, for pearls and information. Report written by Father Jacinto Cortes, a Jesuit.
50	Jesuits		1642	M	First voyage for founding California missions. They furnished missionaries, journalists, cosmographers, and historians to nearly all the government expeditions.
51	Deschnew	R	1648 (R.)	K.	A Cossack, who sailed from north Siberia through the Arctic Ocean and Behring Strait. Neither understood nor published the discovery of this strait. Discovered Kamschatka. Does not mention the American continent.
52	(H) Porter y (Portál de) Casanate.	S	1648	M. and K.	To the east coast of Lower California. Did not reach the mouth of the Colorado.
53	Piñadero	S	1664-'67	K.	Sailed to coast of Lower California for pearls, as also in 1667. No important results. Colorado River not seen.
54	Lucenilla, also Lúzanilla	S	1668	K.	Made similar voyage to that of Piñadero. No important results. Colorado River not seen.
55	Allouez	F	1669	K.	Made discoveries on the Wisconsin River.
56	Marquette	F	1673	Charlevoix and Schoolcraft.	Entered the Mississippi River from the Wisconsin, passed the mouths of the Missouri and Ohio, reached the Arkansas, and returned via the Illinois.
57	Hennepin	F	1680	Warren	Named St. Peter's River and Falls of St. Anthony.
58	La Salle	F	1682 (R.)	K. and Warren	In 1678 started from Canada to find northern route to China. Discovered mouth of Mississippi River.
59	La Hontan	F	1688	K.	Explored the Des Moines River and heard of a great western river running to the ocean (probably the Columbia), 1687, in the vicinity of the Yellowstone Park. Brought to France sketch of a map painted by natives on a buffalo skin.
60	(H) Alondo (Navarrete spells the name Atondo. H.).	S	1683	K.	Cost about 225,000 pesos. Results meager. Explorations in interior. Returned to Mexico 1685. Reached a bay on east coast of Lower California at approx. 26° 30′ north latitude. Accompanied by Father Kuhn, the cosmographer of the expedition, who wrote the report.
61	Coxton, Captain		1688	G	From north Pacific up a long river which ran out of a great lake called Thoyago.

NOTE.—Fonte (fictitious) supposed to have been a Spaniard sailing from Peru in 1640 (G., B., M., and K.). Another pretended voyage by northwest passage came into note in 1708. Brought before French Academy in 1750. Kohl says there was no such man and no such expedition.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
62	Le Sueur	F	1695	Warren	Discovers Blue Earth, or St. Peter River.
63	Salvatierra	I (Jesuit).	1697	G., K., and M.	Founded the first mission in Lower California.
64	Iberville	F	1698-'99	K.	Entered Mississippi River from its mouth. Discovered Lakes Maurepas and Pontchartrain, settling at Biloxi.
65	De Fonte	F	1700	K.	Made expeditions up and down the Mississippi River.
66	Kuhn (Kino)	G (Jesuit)	1701-'02	G., M., and K.	Discovers the peninsularity of Lower California. Dies in 1710, leaving the question unsettled. (K.) Reached the mouth of the Colorado in 1702.
67	Guillen	G (R.)	1719	M.	Makes overland expeditions to California.
68	Ugarte	Jesuit	1721	K.	Sailed along east coast of Lower California, reaching the mouth of the Colorado in July, 1721.
69	Charlevoix	F	1721	K.	Explored along upper Mississippi. Learned from Indians of Missouri heading in high mountains, and of a western river leading to the ocean.
70	Behring	D	1728	G., T., and K.	Reaches northeast extremity of Asia, approx. north latitude 66°. Enters straits called by his name. Stated vaguely that in 1730 Krupischeff and Gwosdef followed Behring, reaching the American coast. (Bancroft.)
71	Varennes de la Vérandrye.	Fr	1731	Rage	Discovers Red River and Lake Winnipeg.
72	Taraval	Jesuit	1732	K.	Explored from approx. latitude 28° north, along eastern coast of Lower California, toward Pacific.
73	Du Pradt (Du Pratz. K.)	F	1735	K.	Learned from a Mississippi Valley Indian more details of the "great western river."
74	Behring (Bering, R.)	D.	1741	G. and T.	Discovers Aleutian Islands, about 60° north latitude. Points to separation between Asia and America. Explores 300 miles of American coast.
75	Steller	G	1741	G. Steller, journey from Kamschatka to America.	First scientific exploration on the west coast near Cape (Island of) St. Elias. (R.)
76	Tchirikof (Tschirikow. K.)	R	1741	G., T., and K.	Discovers Prince of Wales Archipelago.
77	Sedelmayer	Fr	1744	Whipple	Followed the Gila River to the Colorado.
78	Consak	Jesuit	1746	M. and K.	Sailed from eastern coast of Lower California (30° north latitude). Explored lower part of the Colorado River to establish missions. Nearly same route as Ugarte. Reached the mouth of the Colorado July 11, 1746.
79	Verendryes (Verendryes)	F	1753	K.	Made attempts to reach the mountains near the source of the Missouri River.
80	Glottof	R	1762-'65	Bancroft.	Reached Kodiak on trading expedition. From 1745 (Nevódchikof) Siberian merchants made trips to the Aleutian Islands.
81	Synd	R	1766	K.	Follows Kamschatka coast to 66° north latitude.
82	Carver	B	1766-'67	R. and K.	Started from Boston. Visited the upper Mississippi region. Returned for lack of means. Gave the name of Oregon to the "river of the west." (See Carver's map in September number of Journal of Military Service Institution, 1882. Symons: "The Army and the Exploration of the West.")

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
83	Link	Jesuit	1766	K.	Walked across great part of Lower California, establishing its peninsular form. Reached a point twenty or thirty leagues from the Colorado and turned back. Last of the Jesuit explorations.
84	Galvez	S	1767-'68	M	Travels in California, establishing missions in Monterey. Travels by land from San Diego to Monterey. (R.)
85	Krenitzin (Captain Krinitsyn and Lieutenant Lewasheff. K.)	R	1768	G. and K.	Sails to Aleutian Islands. Explores southern part of Alaskan coast.
86	Franciscans	Fr	1769-70	G., T., and K.	Make settlements at San Diego and Monterey.
87	D'Auteroche	F	1769	K.	Occupied Transit of Venus Station at southern extremity of Lower California. Determined its longitude with greater accuracy. Vancouver made comparisons as late as 1793.
88	Portala	S	1769	K.	Overland from Velicata, Lower California, to San Diego. Traversed from Colorado River to San Diego for the first time. Mission of San Diego established.
89	Vila	S	1769	K.	From San Blas, Mexico, to San Diego. Assisting land expeditions and rediscovering San Diego.
90	Portala	S	1769-70	K.	Land expedition in search of Monterey, reaching 37° 45' north latitude, in view of Bay of San Francisco.
91	Perez	S	1770	K.	Sailed from San Blas to Monterey. Reached Santa Barbara only, and returned to San Diego, thence sailed to Monterey, reaching that bay 167 years after Vizcaino.
92	Portala	S	1770	K.	Overland from San Diego to Monterey, founding that mission.
93	Serra	Fr	1770-71	K.	Overland between Monterey and San Diego, establishing missions of San Buenaventura and San Gabriel.
94	Benyowsky	H	1771	G	Visits several Aleutian Islands. No new discoveries.
95	Hearne	E	1771	G	Explores from Hudson's Bay, discovers Great Slave Lake, and follows Coppermine River to the Arctic.
96	Perez	S	1772	K.	From San Blas, Mexico, to Monterey via San Diego.
97	Com. Don Pedro Fages (K.) and Crespi.	S	1772	K.	From Monterey northward toward San Francisco Bay.
98	Perez	S	1774	K., G., T., and M.	From Monterey Bay. From San Blas to San Diego and Monterey, and thence northward to about 54° 20' north latitude, discovering Nootka Sound. Visited several points afterwards claimed to be discovered by the English. (See Humboldt: New Spain.)
99	Anza	S	1774	K.	Overland from Sonora to Monterey. Crossed the Colorado, establishing a new route between California and New Mexico, through Sonora, for supplying the missions.
100	Franciscans	Fr	1776	K.	Mission of San Juan Capistrano established.
101	Heceta with	S	1775	G., T., M., and K.	From San Blas. Discovered the mouth of the Columbia River, but did not enter it. From San Blas to explore northward to 65th degree. Discovered in latitude 57° 2' north a great mountain (Mount Edgecumbe). (See also Barrington; Miscellanies and Maurelle; Diary of the voyage.) Heceta and Ayala sailed together. (K.)
	Ayala and	S	1775	K.	To Monterey, thence San Francisco Bay, making its first survey.
	Bodega	S	1775	K.	Reached 58th degree north latitude.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
102	Garces	Carmelite.	1775	K.	From New Mexico to San Diego, crossing the Colorado, and opening a new route near 35th parallel.
103	Anza	S.	1775	K.	From Presidio San Miguel in Sonora to mission San Gabriel. Crossed the Colorado River.
104	Frobisher	E.	1775	Ruge	Churchill and miss.
105	Anza	S.	1776	K.	Overland, Monterey to San Francisco Bay, making plan of bay from land side. Second land expedition to San Francisco Bay.
106	Quiros and Moraga	S.	1776	K.	Combined land and sea expedition, Monterey to San Francisco Bay. Made further examinations in and around the bay, and discovered the San Joaquin River.
107	Rivera	S.	1776	K.	Monterey to northward, founding mission Santa Clara.
108	Cook	E.	1776–'78	G. and K.	Sails for northwest passage and reaches 69° north latitude. Discovered Nootka Sound and Prince William's Sound, 60° north latitude. Believed firmly in water communication between Behring Straits and Baffin's Bay.
109	Escalante	Fr.	1776–'77	M.	From Santa Fe to border of Great Salt Lake and return.
110	Pond	E.	1778	Ruge	Discovers the Athabasca.
111	Arteaga and Bodega y Cuadra.	S.	1779	G., M., and K.	From San Blas. Searching along west coast for arctic passage. Reached Port Bucareli, 55° 17′ north. (See Maurelle's Diary.)
112	Serra	Fr.	1782	K.	Traveled near coast from Monterey via Santa Barbara, establishing San Buenaventura.
113	Hanna	E.	1785–'86	G. and K.	Visits Nootka Sound. Discovered Fitzhugh Sound. (See Forster: History of Voyages.)
114	Lowrie and Guise	E.	1786	R.	From Nootka Sound to Prince William Sound, and discovers the coast called by Dixon Queen Charlotte Island.
115	La Perouse	F.	1786	G., M., and K.	From Brest. Visits northwest coast between 58° and 54° north latitude, touching at Monterey. Had orders to find the northwest passage. Reached latitude of Mount St. Elias. (Millet Mureau: Voyage de la Perouse au tour du monde.)
116	Peters	E.	1786	G. and K.	From Bombay. Visits Nootka Sound. Probably the first to circumnavigate Queen Charlotte's Island.
117	Dixon and Portlock	E.	1786–'87	G. and K.	From England. Names Queen Charlotte's Island, Cook's River, and Prince William's Sound. (George Dixon: Voyage around the world.)
118	Berkeley	E.	1787	K.	From Ostende, under the Austrian flag. Discovers and names de Fuca Straits, and thence explored southward along the coast. Discovered Cape Classet, Barclay Sound, and showed Vancouver to be an island. Reached Nootka Sound. (See Greenhow and Forster's Voyages.)
119	Duncan	E.	1788	G.	Discovered Prince of Wales Archipelago.
120	Martinez	S.	1788	K.	From San Blas by sea to Russian settlements (Unalaska) on the Aleutian Islands. Explored also de Fuca Straits. Reached Prince William's Sound. (See Navarrette; Humboldt.)

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXPLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
121	Meares and Douglas	E	1788	G. and K.	From Calcutta. Fur-trading expedition. Visits Cook's River, Nootka Sound, and names Straits of Fuca. Recognized coast of New Albion to latitude 45° north. Reached Prince William's Sound. Took possession in name of Queen. (See Hugh Murray: Historical account of discoveries in North America.)
122	Kendrick	A	1788	G	From Boston. Explores east coast of Queen Charlotte's Sound. Reaches Nootka Sound.
123	Martinez	S	1789 (R.)	G., M., and K.	From San Blas. Explores de Fuca Straits. Reached Nootka. Military trip to prevent English commerce. Claimed the whole coast for the King of Spain. (See Greenhow.)
124	Colnett	E	1789	Navarrete	Sailed February 17, 1789, from San Blas, under orders of the King of England, to fortify the harbor of Nutka (Nootka). (R.)
125	Narvaez	S	1789	M	Reaches Nootka in search of Straits of Fuca.
126	De Haro	S	1789	K	Explored de Fuca Straits.
127	Fidalgo	S	1789 (K.)	M	Explores coast north from Nootka to near 61° north latitude. Reached Prince William's Sound.
128	Elisa	S	1789 (K.)	G., M., and K.	Visits Nootka Sound and Cook's River. Discovered Puget's Sound. Takes possession for the King of Spain.
129	Billings	E	1790	G	From Ocotsk. Visits Aleutian Islands. No new discoveries.
130	Quimper	S	1790	G., M., and K.	Explores Straits of Fuca. Discovered Neah Harbor. Claimed for Spain. Reached Prince William's Sound.
131	Elisa	S	1791	M. and K.	More complete exploration of Straits of Fuca.
132	Vancouver	E	1791	G. and K.	Sails to examine Pacific coast, 35th to 60th degree north latitude.
133	Malaspina (K.)	S	1791	G., M., and K.	From Acapulco. Sails to explore the fictitious "Straits of Anian." Reached 60° north latitude opposite Mount St. Elias. Did not find, and denied the existence of a northwest passage. Made few discoveries, but many exact determinations. (See Navarrete; Humboldt, New Spain.)
134	Marchand	F	1791	G. and K.	From Marseilles. Visits Norfolk Sound, near 58° north latitude. Reached Sitka. Made very few observations. (See Marchand: Voyage au tour du monde.)
135	Ingraham	A	1791	G	Visits northwest coast.
136	Gray	A	1791	G	Revisits Straits of Fuca. Discovered Gray's Harbor.
137	Vancouver	E	1792	G. and K.	From Falmouth. Examines west coast, Straits of Fuca, etc. Furnished the first exact map of the lower Columbia. Found high mountain ranges along the coast; recognized these from California to Alaska. Showed "Cook's River" to be a bay, and named it Cook's Inlet. Destroyed the illusions about a northwest passage.
138	Gray	A	1792	G. and K.	Enters Columbia River near its mouth. This river was believed by Aguilar to have been a bay.
139	Caamaño	S	1792	G. and K.	Explores coast northeast of Queen Charlotte's Island. From San Blas, Mexico, March 20, 1792.

CHRONOLOGICAL STATEMENT OF VOYAGES AND EXLORATIONS, ETC.—Continued.

No.	Name.	Nation.	Year.	Authority.	Remarks.
140	Galiano and Valdes	S	1792	G., M., and K.	From Acapulco. Explores Straits of Fuca and coast between 48° and 50° north latitude. The end of the Spanish expeditions. Discovered Fraser River.
141	Mackenzie	E	1793	T., B., and K.	Discovers Fraser's River and crosses "Rocky Mountains" to Pacific at the Cascades. First to traverse parts of the Columbia in a boat. A most important exploration.
142	Broughton	E	1795-'96	K.	Reached Nootka in 1796 from Sandwich Islands. Sailed thence to Monterey. (K.)
143	Krusenstern and Lysiansky.	R	1803-'06	K.	From Cronstadt. Explorations in northern parts of Russian America, 1804-'05. Principally commercial.
144	Chwostoff and Davidoff	R	1806	K.	Sailed from Sitka to San Francisco, making examinations of the coast, returning to Sitka.
145	Beechy	E	1827	K.	Coasted from Bering's Straits as far south as Monterey. Made map of San Francisco Harbor.
146	Belcher	E	1836-'43	K.	Coasted and reconnoitered from opposite Mount St. Elias to Cape St. Lucas in 1837, also in 1839. Explored and surveyed the Sacramento River.
147	Fur companies	A and E	1806-'21	K.	The Northwest, Pacific, and other fur companies explored and operated in the Northwest and along the Columbia River. The Northwest Company at one time had 25,000 "voyagers" in employ.
148	Kotzebue	R	1815-'18	K.	Instructed to sail through Bering's Straits eastward to Europe. Discovered Kotzebue Sound. Believed there was water communication, because of southern current through Bering's Straits.
149	Hudson Bay Company	E	1821-'41	K.	All fur companies united, with headquarters at Fort Vancouver (see Franklin, Richardson, Parry, and others), occupied the waters of the great Northwest.
150	Russian explorations	R	1812-'41	K	Made settlements and stations on the California coast up to 1841, at Bodega Bay (Port Romanzoff), etc.
151	Mission expeditions	Fr		K.	Excursions made from San Francisco inland and between Mexico, New Mexico, and the California coast, at least up to 1811.
	French explorations	Fr	1820-'40	K.	Expeditions of circumnavigation, touching at the usual places in the North Pacific, making observations and reconnaissances at and about harbors, bays, and lakes.
	De Mofras	F	1844	K.	Parts of interior of Pacific coast. Last of the French explorations.
	Slacum	A	1836-'37	K.	Traveled through Mexico to Guaymas. Made notes and sketches at mouth of Colorado River and elsewhere. (See Senate Ex. Doc. No. 24, Twenty-fifth Congress, second session.) No latitudes or longitudes.

NOTE.—For List of the Explorers, see Bancroft, Northwest Coast, vol. I, chap. X, pp. 310-342. List on pp. 340-342.

The principal published authorities on the grand achievements in explorations and surveys on the west coast, of the sixteenth, seventeenth, and eighteenth centuries (undertakings without a parallel in the past, when all the attendant circumstances are considered, and never to be equaled in the future), are found at length in the Kohl manuscript, while some of them, together with others consulted by myself, are herewith:

Hakluyt: Vol. III. Voyages and Navigations. London, 1600.
Ramusio: Delle navigationi et viaggi.
Navarrete: Coleccion de los viajes y descubrimientos.

Gomara: Historia general de las Indias * * * con la conquista de México y de la Nueva España. Saragoça, 1552-'53.

Venegas: Noticia de la California. Madrid, 1757.

Herrera: Historia general, etc. Madrid, 1730.

Burney: A chronological history of voyages and discoveries in the South Sea and Pacific Ocean. 5 vols. 4°. London, 1803.

Purchas Pilgrims: Vol. III. London, 1625.

Humboldt: Essai politique sur le royaume de la Nouvelle Espagne. Paris, Schoell, 1811. 2 vols. in 4°.

Greenhow: History of Oregon and California. Boston, 1845.

Mofras: Exploration du territoire de l'Oregon, etc. 2 vols. Paris, 1844. [Mofras gives a chronological bibliography on p. 465, vol. 2.]

Abert: Examination of New Mexico. 1846-'47.

Whipple: Vol. IV. Pacific Railroad Reports.

Reports, U. S. Coast and Geodetic Survey. Appendix 19, 1884, and Appendix 7, 1880.

Bancroft: History of the Northwest Coast. Vol. I, 1543-1800, 8°, pp. 735. List of authorities, pp. XVII-XXVIII.

Bancroft: History of Central America. Vol. I, 1501-'30. Summary of Geographical Knowledge to the year 1540, pp. 97 et seq.

Narrative and Critical History of America. Discoveries on the Pacific Coast. Vol. II, pp. 431-472. Early Explorations in New Mexico, pp. 473-504.

Ternaux-Compans (Henri): Voyages, relations et mémoires originaux pour servir à l'histoire de la découverte de l'Amérique. Paris, 1837-'41. (Two series, 10 and 8 vols.)

Recueil de Voyages et de documents pour servir à l'histoire de la Geographie depuis le XIII^e jusqu' à la fin du XVI^e siècle. Jean et Sébastien Cabot.

D'apres des documens's inedit, par Henry Harrisse. Paris, Ernest Leroux, ed., 28 rue Bonaparte, 1882. Bibliographie, pp. 369-375.

OLD MAPS.

A number of photolithographs from tracings of old maps are here introduced, with a legend page facing each, intended to illustrate, though rudely and irregularly, the process of geographical information as to the North American continent between 1500 and 1800, so far as the same has been shown cartographically. While these maps are not *all* standard or typical at their dates of issue, having been selected principally from the collections made by the late Dr. J. G. Kohl and atlases found in the Congressional Library,* they are, nevertheless, suggestive, and may lead to a more critical review of the progress of American discovery, exploration, and cartography from the earliest discoveries to the commencement of the nineteenth century, from an historical and scientific standpoint which exceeds the scope of the present memoir, that proposes simply an introduction to the epitome of Warren's Memoir, and the further résumé of Government explorations and surveys within the confines of the United States.

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*Copies of Hondius, edition 1609, and Senex, 1710, were furnished by and through the courtesy of Assistant J. C. Lang.

THE ISLAND OF ANTILIA, BY BENINCASA, 1463.

This is of interest principally because it may be considered as one of the first maps indicating larger countries to be found to the west of Europe.

NOTES BY KOHL.—This map is a copy of a part of a map which is to be found in a portolano of Benincasa.

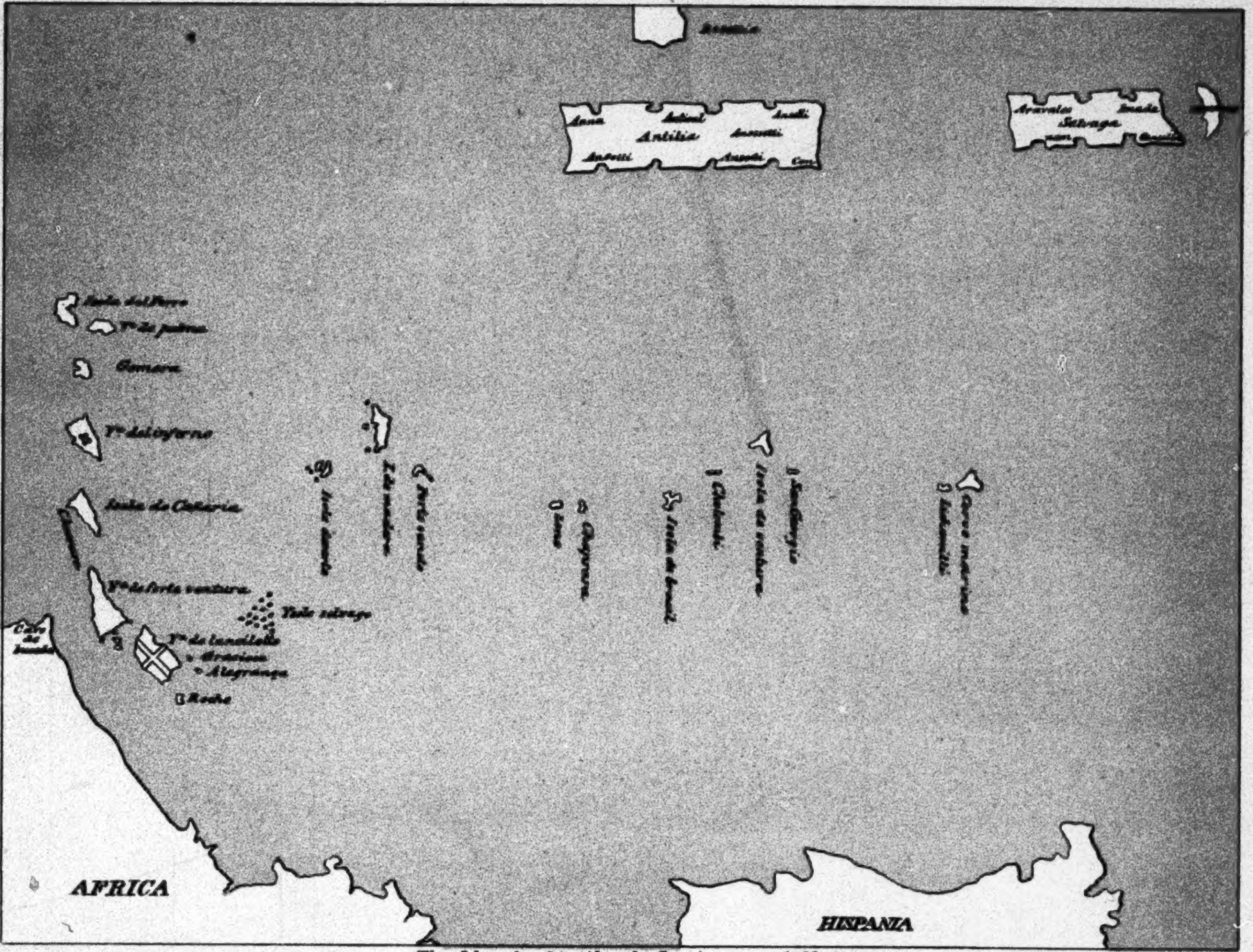
Benincasa was an Italian, who composed, between 1463 and 1473, different portolanos, which are mentioned in the work of the Vicomte de Santarem, "Histoire de la Cosmographie," vol. I, p. xlii.

Our map is taken from his portolano of the year 1463. It is remarkable—

(1) Because it has in the latitude of Spain *the Island of "Antilia,"* nearly as large as Portugal, and two other large islands to the west and north of it named "Rosellia" and "Salvaga," which islands appear in the same or a somewhat varying manner and shape on many other maps, and may be considered as *the first indication of larger countries to be found to the west of Europe.*

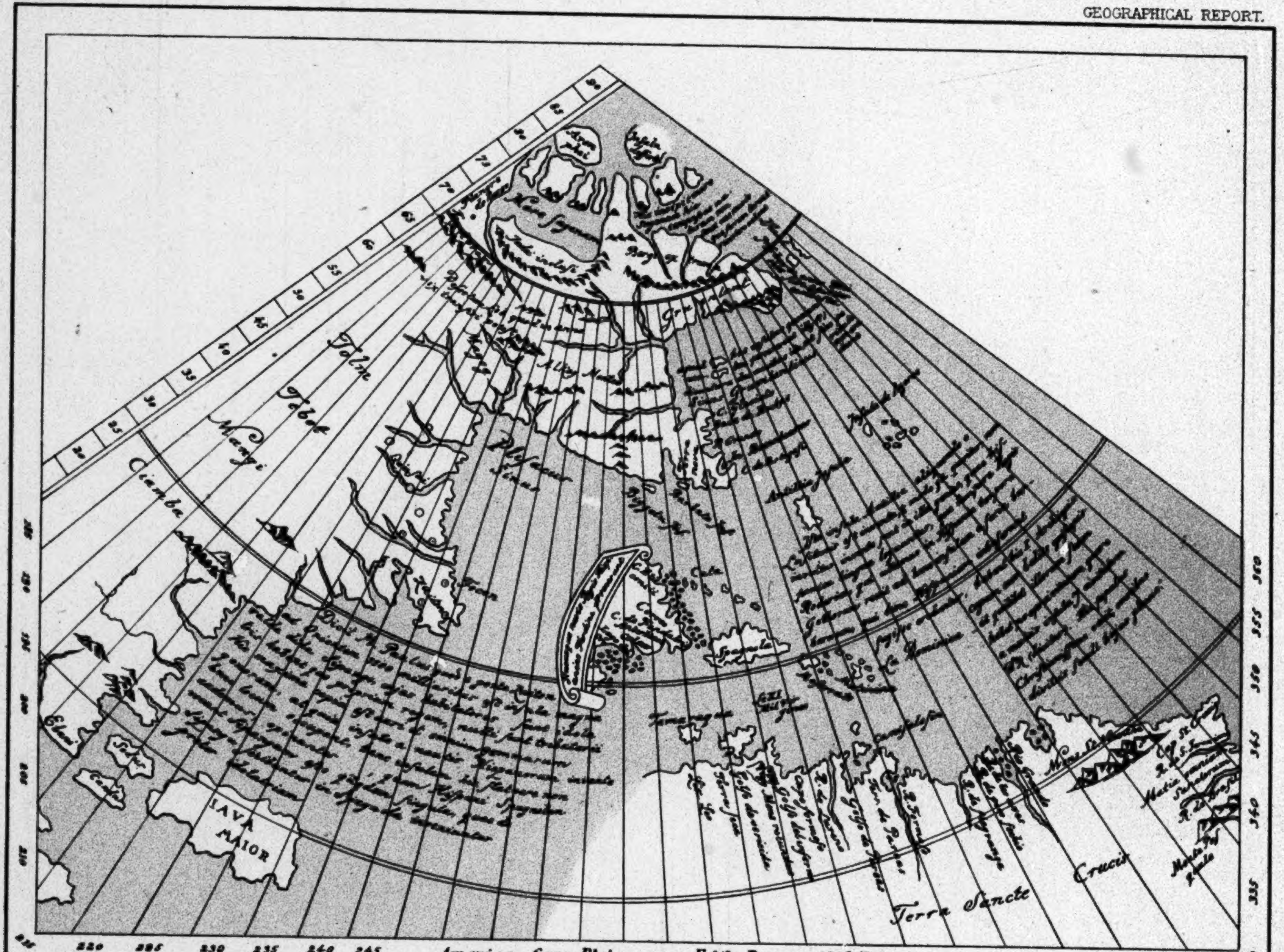
(2) Because a whole chain of islands extends on it midway between the Canarian Islands and Ireland. Also this chain of western islands is to be found in a similar manner on different other maps of the middle of the fifteenth century. (See Santarem, Hist. de la Cosmographie, I, p. xlii, and III, p. 177; also Winsor-Kohl collection of early maps. Bibliographical Contributions, Harvard College, No. 19, p. 47; No 245.) Under No. 20, p. 8, A. D. 1455, reference is made to a sea chart by Bartolomeus de Pareto, showing "Antilia" and an island farther west named "Roillo;" also No. 21, p. 8, A. D. 1476.)

A portolano by Andreas Benincasa, given in St. Martin (Pl. VII) and Lelewel (Pl. XXXIV). It shows "Antilia" as a western island, and the "Isola de Braçill" west of Ireland.


Antilia
Anna
Salvaga
Isola del Ferro
Gomera
Isola de Canaria
Ysole salvage
Alegranza
Rocho
Isola de brasil
Isola de ventura
AFRICA
HISPANIA

The Island of Antilia by Benincasa, 1463. (Reduced)

Julius Bien, Photo-lith.


Tolm
Tebet
Mangi
Ciamba
IAVA MAIOR
Terra Sancte Crucis
Mare Sugenum
Golfo de Parias
Terra de Parias
R. de Lareno
Capo formoso
Golfo dele ofernos
Capo Mono rotundo
Golfo de vericida
Terra seca
Lo Lo
R. de Brasil
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America from Ptolomaeus, Edit: Romae, 1508. (Reduced)

Julius Bien, Photo-lith.

AMERICA FROM PTOLOMAEUS, EDIT. ROMÆ, 1508.

This map at its date (1508) was the most complete and reliable compilation extant of what was then known in regard to America. It was issued five years before Balboa discovered the Pacific Ocean.

NOTES BY KOHL.—This is a copy of a part of the celebrated map of the world added to the edition of Ptolomaeus, Rome, 1508. Humboldt, who in his works alludes often to this map and has given most valuable critical notes upon it, says that it has been drawn and composed *by the German Johannes Ruysh.* It was revised and corrected by two Italians, Marco of Benevent and Jonnes Cotto of Verona ("Correcta a Marco Beneventano et Joanne Cotto Veronensi"). (See upon this most interesting map Humboldt in the preface to Ghillany's German work on Martin Behaim, and Walkenaer in his "Recherches géographiques sur l'intérieur de l'Afrique septentrionale," p. 186, and, also, Biographie Universelle, tome VI, p. 207).

The title of this map is "Universalior cogniti Orbis Tabula ex recentibus confecta observationibus" (a more universal table of the known world compiled from modern observations). The principal features of this map are the following:

"*Terra Nova*" (Newfoundland), in its eastern and southern coast very well represented, is given as a *peninsula of Asia.*

"Gruenlant" or "Gruentlant" (Greenland) is likewise a peninsula of Asia, of which the countries and provinces of Mangi, Ciamban, Tebet, the points "Quinsai," "Zaiton," and the islands "Java Major" (Borneo ?), "Java Minor," and "Candyn" (?) appear. *Japan (or Zipangu) is omitted* because the author, as he says in a Latin inscription, believed that this island was now found by the Spaniards in another place, and called by them "Spagnola."

This "Spagnola" (our Haiti) he puts about sixty degrees of longitude to the west from the meridian of Ferro, and north of the tropic of Cancer. To the southeast of it he adds some of the smaller Antillian Islands—"La Dominica," "Monferrato," "Matinina" (Martinique).

To the northwest of "Spagnola" appears a country which is no doubt Cuba, or Fernandina, or Isabella, though not indicated by name. That Cuba, and Cuba only, is meant, seems evident from the mass of small islands on the north coast as well as on the south coast of this land, though it reaches as high as 40° north latitude. These groups of islands appear to be those innumerable little rocks and isles which Columbus called the Garden of the King and the Garden of the Queen.

On the south coast they are all collected in a kind of bay, which we afterwards find repeated on many subsequent maps, and of which some others have erroneously supposed that the Gulf of Mexico was indicated by it.

A Latin inscription in the west says that the King of Spain's ships did not come as yet farther, and intimates that it was unknown if this country was an island or not. This question was only settled in the year 1508, on the circumnavigation of Cuba by Ocampo. Nothing more appears of North America. Of South America, which is called "*Terra Sancte Crucis*" (the Land of the Holy Cross, after Cabral), sive Mundus Novus (the New World), nothing appears but the northern coast as far west as Ojeda (1501) discovered it, and the east coast as far south as the 38th degree south latitude. On the west coast is an inscription which says that the Spaniards had not yet penetrated farther.

The Latin inscription in the interior of South America gives a description of the natural productions of the continent, and another Latin inscription at the south end of the coast says the Portuguese navigators came as far down as 50° south latitude, but did not reach yet its southernmost end.

The editor of the Ptolomaeus, to which this map is added, makes in the book itself the further remark that he was unable to find that part of the map which related to these southern regions.*

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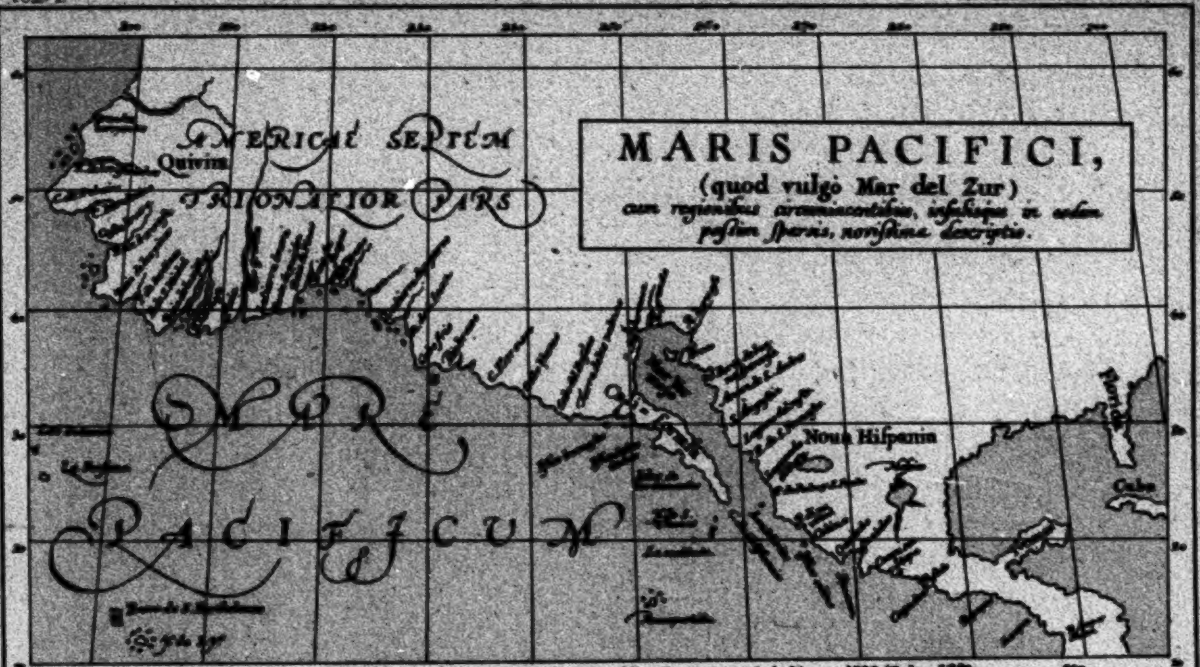
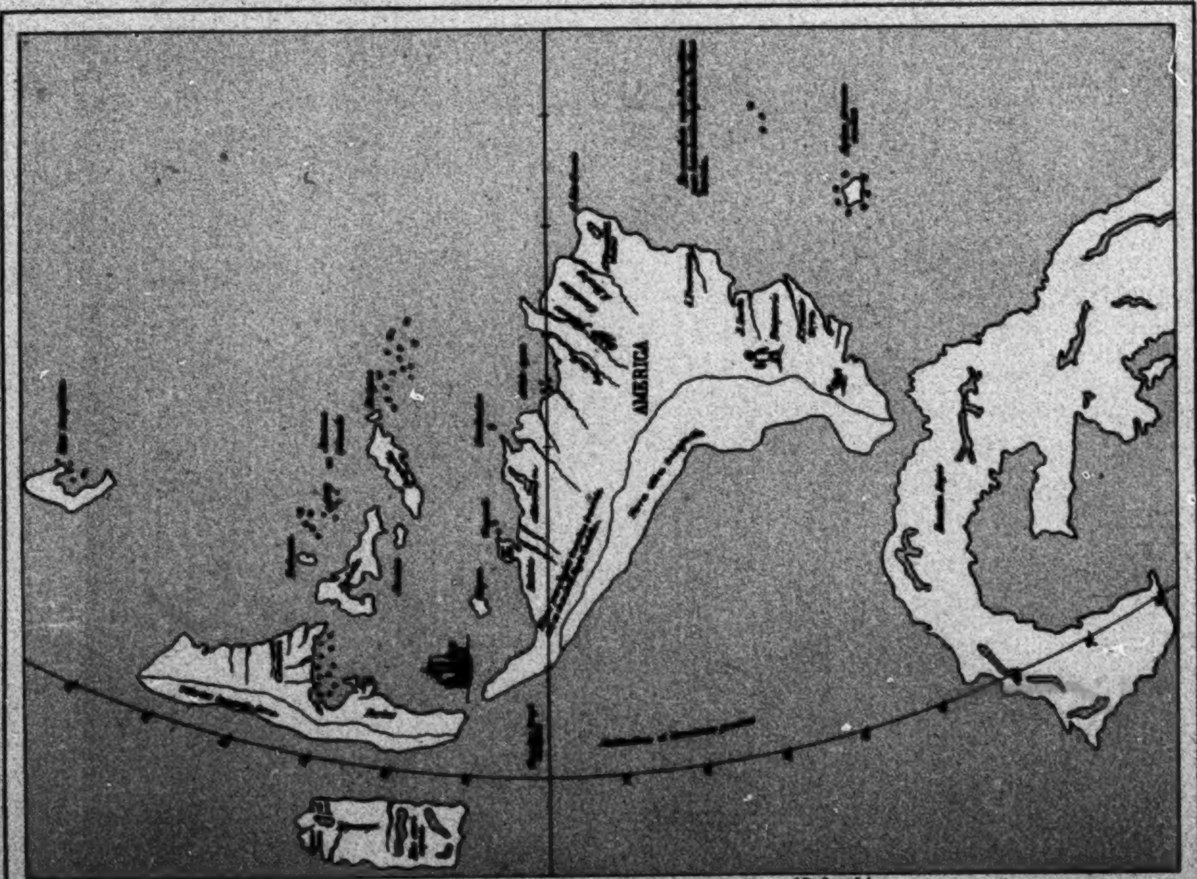
* See also Winsor: Kohl collection, No. 28, p. 9, Bulletin No. 19.


MARIS PACIFICI,
(quod vulgò Mar del Zur)
cum regionibus circumiacentibus, insulisque in eodem passim sparsis, novissima descriptio.
AMERICAE SEPTEMTRIONALIOR PARS
Quiuira
MARE PACIFICUM
Noua Hispania
Florida
Cuba

From Map of North America by Abrahamus Ortelius, 1589 (Reduced.)



America from a Globe in Frankfort, about [illegible]. (Reduced.)

Julius Bien, Photo-lith.

AMERICA, FROM A GLOBE IN FRANKFORT, ABOUT 1520.

This is notable, since it is believed that it is the first map upon which the name "America" appears.*

NOTES BY KOHL.—This is a copy of a part of a map which depicts America. The drawing is contained on an old globe of the world in the city library of Frankfort on the Main.

Neither the date nor the author of the map or globe are indicated, but the whole design agrees in all its principal features with the map given on the globe of I. Schöner, of the year 1520, preserved in Nuremberg (see our collection). We know that Schöner made different globes, and that of Frankfort may also be one of them.

The same as on the globe of Nuremberg, so also on this, *America is divided in two great islands* and different smaller ones. These two islands have nearly the same configuration, and are represented on their western coasts as unknown and unexplored. On both maps the northern reaches as high as 50° north latitude, and the southern as far as 40° south latitude, where on both maps is a strait.

The Antilles have on both globes the same configuration, distances, and number, and the same may be said of "Zipangu" (Japan). On both maps a vessel stands near the strait which passes through the northern and southern islands.

A nearer comparison, however, shows many different variations on both globes. At first our present map is neither so rich in names nor so special in the representation of the coast. Then the imaginary southern contiment has on our map quite another shape than on that of Nuremberg, and the same may be said of that northern island which stands for Labrador and indicates the discoveries of Cortereal. Besides this, many of the inscriptions and names on our map differ from the map contained on the globe of Nuremberg. It is therefore evident that the one is not a mere copy of the other, but that they are different independent works, made, perhaps, by the same author (Schöner?) but at different times. Because on our globe everything is less perfect and complete, it is very probable that it was constructed at an earlier period, where Schöner perhaps had not yet made so many studies of his subject. It seems that we must put it at all events *before* 1520, perhaps about 1515, and this globe, therefore, may be considered *the first map on which the name "America" occurs.* The southern continent is called "*Brasilia Regio*" (the region Brasilia). On the globe of Nuremberg it is called "Brasilia inferior."

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* Winsor says, p. 11, Bulletin 19, etc., No. 34: "Wieser, in his Magalhães-Strasse (p. 19), where an engraving of it is given, declares it to be the globe made to accompany Schöner's Luculentissima quædam Terræ totius Descriptio, printed in 1515, and of which two copies are now known." See also Nos. 35 and 36, same page.

FROM MAP OF NORTH AMERICA, BY ABRAHAM ORTELIUS, 1589.[*]

This map was among the best of those of America extant toward the close of the sixteenth century. The Pacific coast had already been reconnoitered above the 57th parallel by Gali.

The Ortelius has been referred to as the prototype of the modern atlas. The publication was continued to at least 1612. His map of the world appears to have been fashioned after Mercator. He prefixed to his book a list of authorities from whose labors he had constructed his own maps. The titles are wholly of the sixteenth century, and not a single Spanish one appears among them.

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[*] Stevens says of Ortelius: "He was a bibliographer, a cartographer, an antiquary, * * * a good mathematician and geographer, and * * * gave his authorities." In 1570 Ortelius published at Antwerp the first edition of his Theatrum Orbis Terrarum, fifty-three copper-plate maps, engraved by Hogenberg. In 1589 there was Marchetti's edition at Brescia and a Latin one at Antwerp. (Narr. and Crit. Hist. of America.) The atlas of 1570 was one of the most celebrated geographical works of the sixteenth century, of which there have been many subsequent editions in Dutch, German, French and Italian, in which the number of maps has been much increased.

In 1606 the first English edition appeared, while the latest Italian one noted is 1697, but meanwhile other cartographers had taken the field. He was the first to collect and compile from contemporary maps. His learning, integrity, and discriminating judgment has made his atlas valuable as a trustworthy record of the best geographical knowledge of his time. (See Narr. and Crit. Hist. of America, vol. III, p. 34.)

NORTH AMERICA, BY ZALTIERI, 1566.

Remarkable in that it is reputed to be the first map upon which the Straits of Anian (Stretto de Anean) appear.

NOTES BY KOHL.—This is a copy of a printed map of North America preserved in the imperial library in Paris. It has an Italian inscription as follows:

"The design of what has been discovered of New France, which we have received lately from the newest navigations of the French to those places, in which are to be seen all the islands, ports, capes, and places of the land which are in the same."

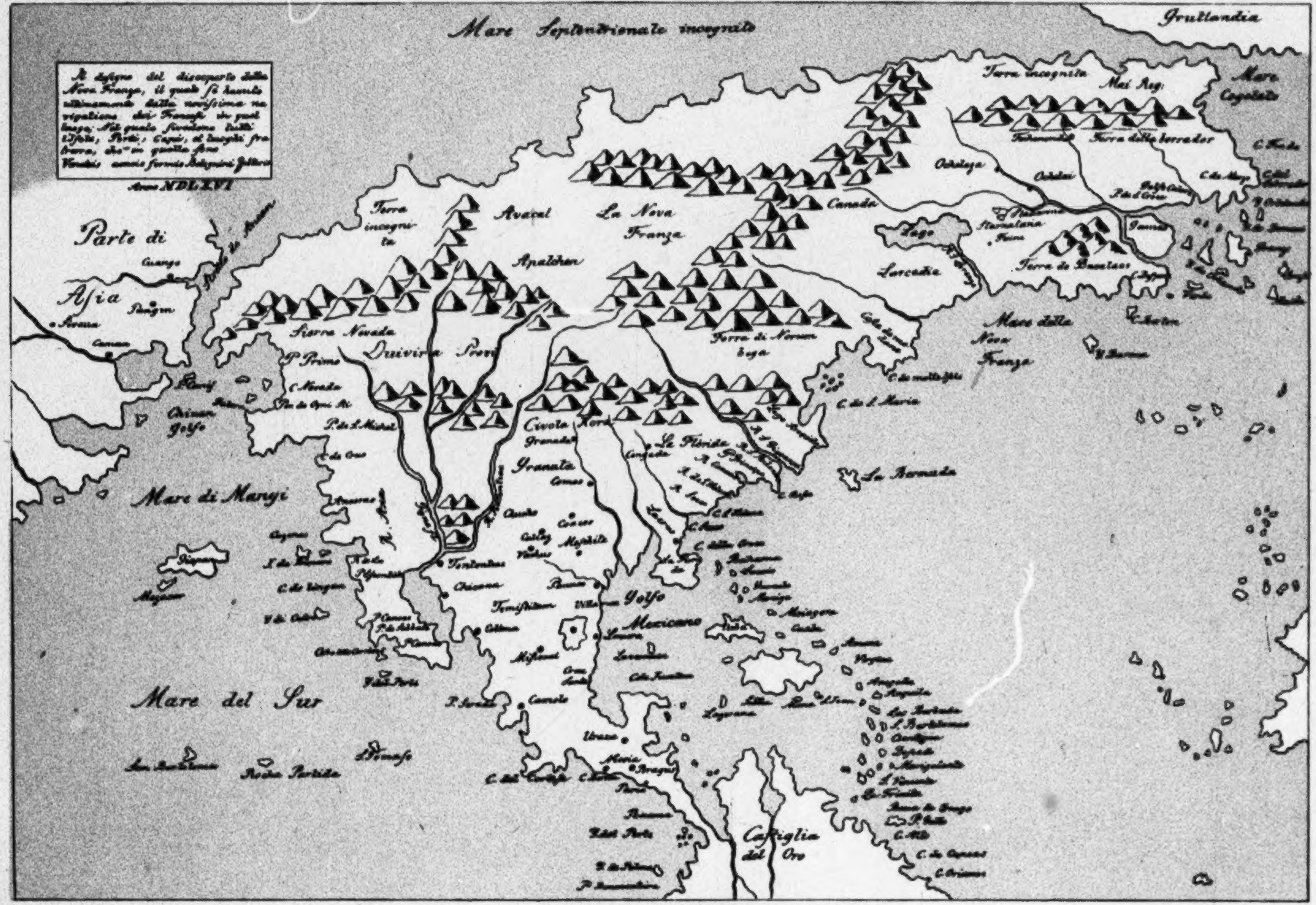
"In Venize, engraved on copper by Bolognino Zaltieri, in the year 1566."

Unhappily this map has neither latitudes nor longitudes, not even the tropics, nor any indication of a measure by miles.

In *the general configuration of North America it resembles very much other maps made at the same time in Italy.* It has in the north "Grutlandia" (Greenland?), and in the west "Giapan" (Japan), and the Strait of Anian in the same manner. (See Italian maps of this time in our collection.)

It resembles, particularly in its general features, *the map of P. Furlani*, produced at the same place (Venize) and some years before (1560). The mountains on both maps are made in the same manner. The river systems of the St. Lawrence and of the rivers of the Californian Gulf are very much alike, and so is the great ever-long northeastern wing given on both maps to North America. Zaltierio (if we may consider him as the author of this map) only deviates in this from Furlani, that he separates America from Asia by the Strait of Anian, which Furlani did not.

Some further peculiarities of his map are the following: He puts *the name La "Nova Franza" (New France) in the center of North America.* He has Newfoundland still dissolved in many islands. To the west of it he has the same river system of the St. Lawrence as Furlani, but he gives no name to this river. Besides, however, he has to the southwest of it a great lake, "Lago," and coming out from it a river which he calls "R S. Lorenzo" (St. Lawrence River), and which empties into the sea on the coast of New


Il disegno del discoperto della Nova Franza, il quale s'è hauto ultimamente dalla novissima navigatione dei Franzesi in quel luogo, Nel quale si vedono tutte l'Isole, Porti, Capi, et luoghi fra terra, che in quella sono
Venetiis aeneis formis Bolognini Zalterii
Anno MDLXVI
Mare Septentrionale incognito
Grullandia
Mare Congelato
Terra incognita
Mai Reg.
Terra del laborador
Ochelaga
Canada
La Nova Franza
Avacal
Apalchen
Terra incognita
Parte di
Asia
Sierra Nevada
Quivira Provi.
P. Primo
C. Nevada
P. de S. Michel
Terra di Norum bega
Lago
Larcadia
Terra de Bacalaos
Mare della Nova Franza
C. de S. Maria
La Bermuda
Civola Granada
Granata
La Florida
Mare di Mangi
Mare del Sur
Golfo Mexicano
Tontonteac
Chiaman Golfo
Giapan
Castiglia del Oro

North America by Zaltieri, 1566.   (Reduced)

Julius Bien, Photo-lith.

England. *This is a great curiosity*, and proves that the rivers and inlets of Maine (Penobscot?) were considered as branches of the St. Lawrence, or as outlets of the Canadian lakes, of which lakes already Cartier had brought home some report.

Something not less extraordinary is also the position of the name "Apalchen" (Apallachian Mountains?) in the center of the whole continent. The author had perhaps read something of De Soto's expedition.

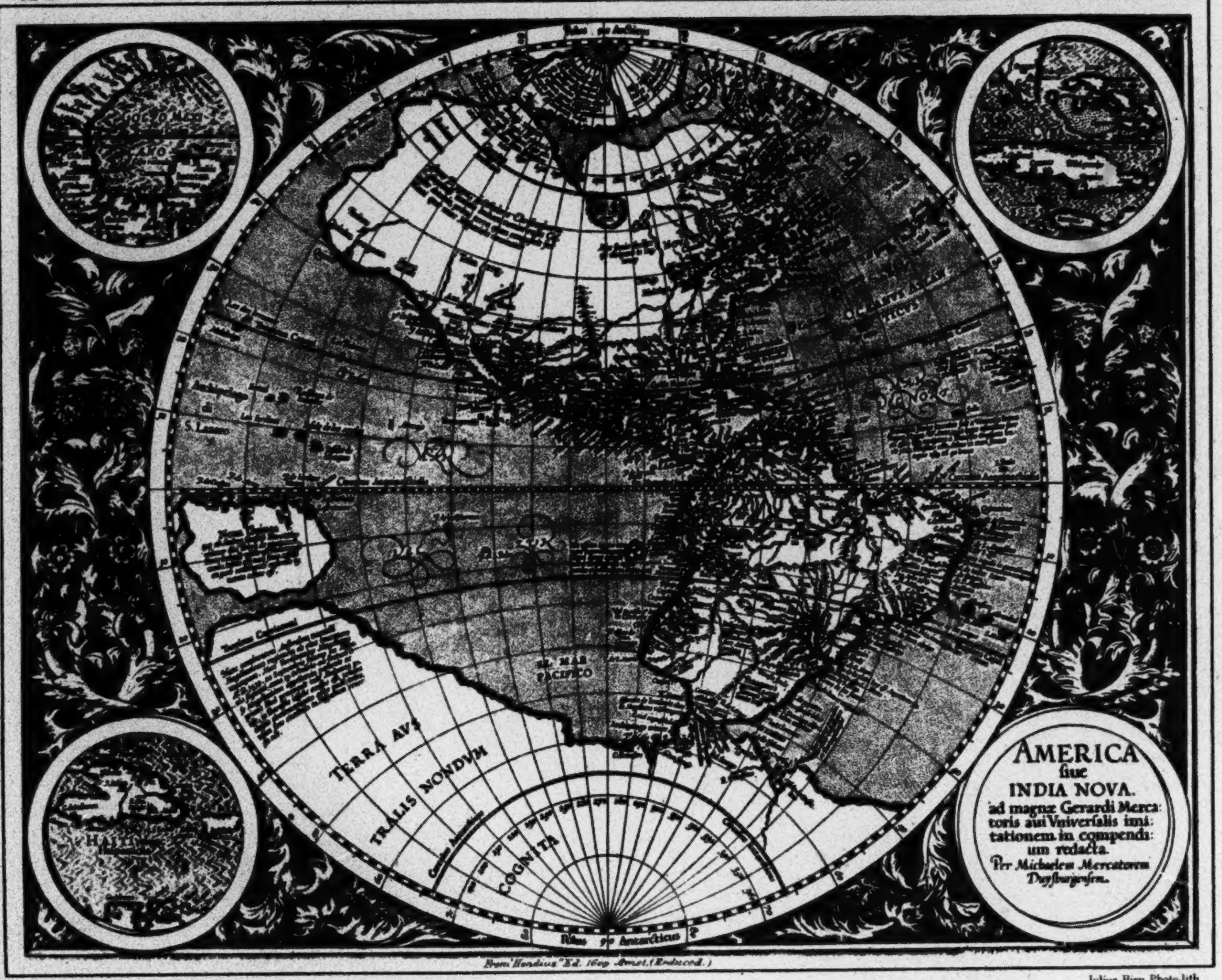
It is not easy to say to which "newest French expedition" (novissima navigatione dei Franzesi), of which he lately (ultimamente) received his information, the author alludes in his inscription. The latest French expeditions were those of Ribaut and Laudennière to Florida (1554), but of those the author takes on his map no notice at all. The coast of Florida is given according to the old Spanish authorities.

The latest French expeditions to the regions of the St. Lawrence were those under Roberval since 1541.

NOTE.—Kohl assumes this to be the first map upon which the "Straits of Anian" appear. (See p. 51, Winsor, A. D. 1558, referring to a map by Martines, presumably of the above date, as one of the earliest to contract the water separating America from Asia to the dimensions of a strait; also p. 20, No. 94, where Winsor compares this map with one by Des Liens (North America), same year (1566). See, also, p. 17, No. 69, A. D. 1566.) A copy of this map is found reproduced on p. 451, Narr. and Crit. Hist. of America, vol. II, and a sketch, also, on p. 93 of vol. IV.

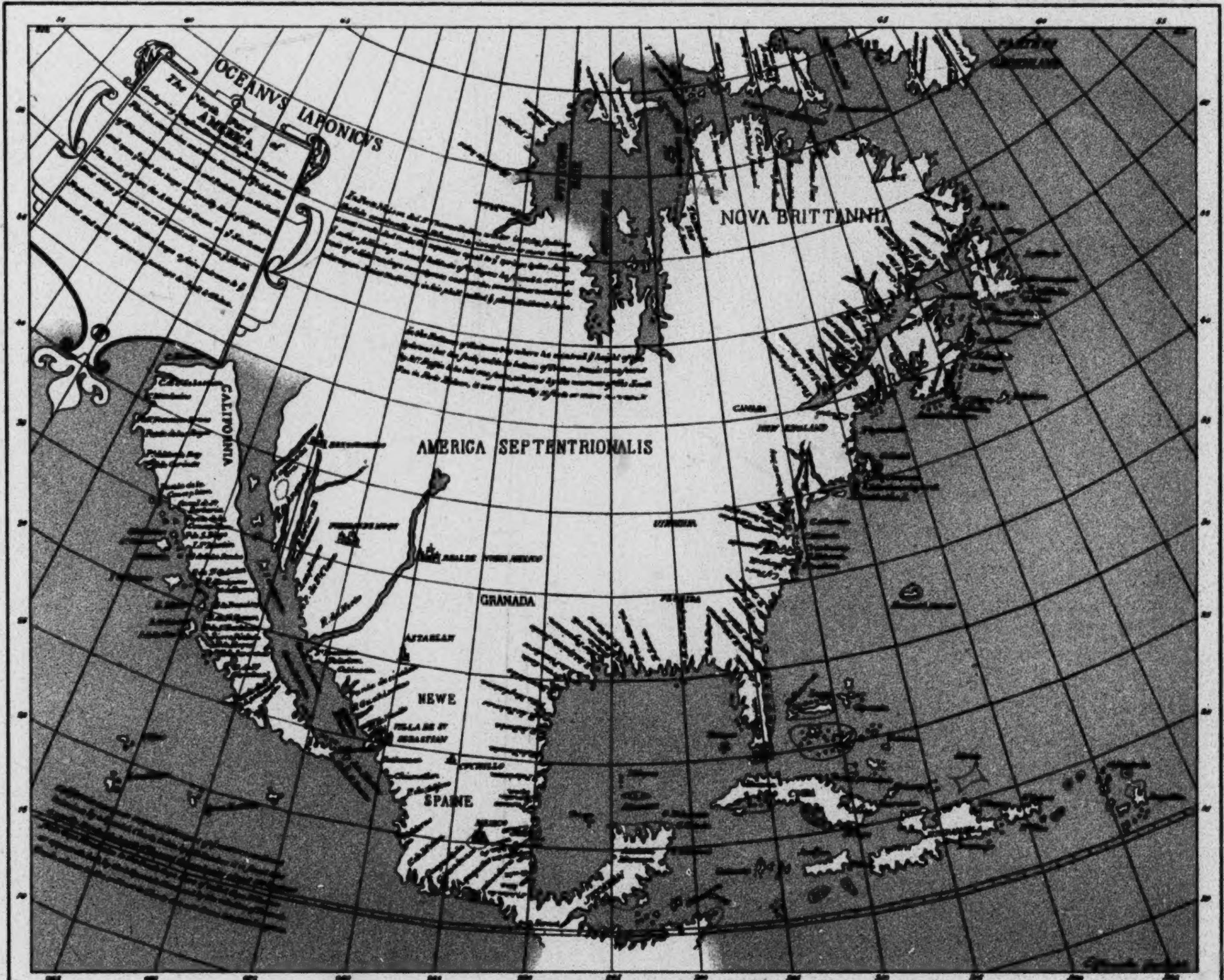
FROM "HONDIUS," ED. 1609, AMST.

Hondius was a celebrated Dutch geographer, who edited with Gerard Mercator a once famous atlas of the world and drew many maps. In 1604 he bought Mercator's plates. He issued a new edition in 1606, to which fifty maps were added, including a few American ones, and thus began the Hondius-Mercator Atlas. He died in 1611 (p. 374, vol. IV, Narr. and Crit. Hist.).


AMERICA
siue
INDIA NOVA.
ad magnæ Gerardi Mercatoris aui Vniverſalis imitationem in compendium redacta.
Per Michaelem Mercatorem Duyſburgenſem.
Polus 90 Arcticus
Polus 90 Antarcticus
TERRA AVSTRALIS NONDVM COGNITA
EL MAR PACIFICO

From "Hondius" Ed. 1609 Amst. (Reduced.)

Julius Bien, Photo-lith


OCEANVS IAPONICVS
The North part of AMERICA
NOVA BRITTANNIA
AMERICA SEPTENTRIONALIS
CALIFORNIA
CANADA
NEW ENGLAND
VIRGINIA
FLORIDA
GRANADA
NEWE
SPAINE
VILLA DE ST SEBASTIAN

North America from Purchas, 1625 (Reduced)

Julius Bien, Photo-lith.

NORTH AMERICA, FROM PURCHAS, 1625.

This map was constructed after the first voyages of Hudson, Button, and Munk (1610–'19), intending to prove the possibility of a northwest passage through which fictitious accounts of pretended voyages by Maldonado, Juan de Fuca, and Fonte had been published. California is shown as an island.

NOTES BY KOHL.—This is a copy of a map contained in the third volume of Purchas's Pilgrims, London, 1625.

Purchas calls it "*the north part of America,*" and adds it to a little "Treatise of the northwest passage to the South Sea, through the continent of Virginia, and by Fretum Hudson."

Neither in this treatise, nor on the map, nor in the preface of his work, nor in the index of the maps contained in his work, Purchas says by whom and how this map was composed. On the map we find only that "R. Elstracke" *engraved* it.

Nearly all other maps in Purchas are bad and reduced copies from Hondius and others. *But this has some original value.* It was made soon after the first voyages of Hudson, Button, and Munk (from 1610–'19) to Hudson's Bay, *with the intention to prove by it the possibility of a northwest passage.* The treatise and the long inscriptions on the map itself contain an explanation of it.

Purchas says that it would be easy to sail through Hudson's Bay to the Western Ocean, and particularly to the waters of California.

Where "Button wintered," he says (near Fort Nelson), "the tides were 15 feet high, and they were particularly high with a western wind, which could only be explained by a connection of Button's Bay with the Western Ocean, which could not be far distant."

Besides this there was still much hope for open water between Button's Bay in the west and the bay in which Hudson wintered in the south. On

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NOTE.—Winsor, on p. 18 of Bulletin No. 19, gives: 62, A. D. 1589. "The World, by Hondius. An engraved map, on which a statement that it is intended to show the tracks of Drake and Cavendish is signed by Jodicus Hondius, 1589. * * * In an inscription referring to the Tierra del Fuego group, Hondins remarks that Cavendish and the Spaniards do not accept Drake's views making a continent the southern boundary of the Straits of Magellan, and on later maps Hondins seems to have accepted these other views. (See Uricoechea, No. 25.)" In edition of 1609, above, a wide stretching continent is shown.

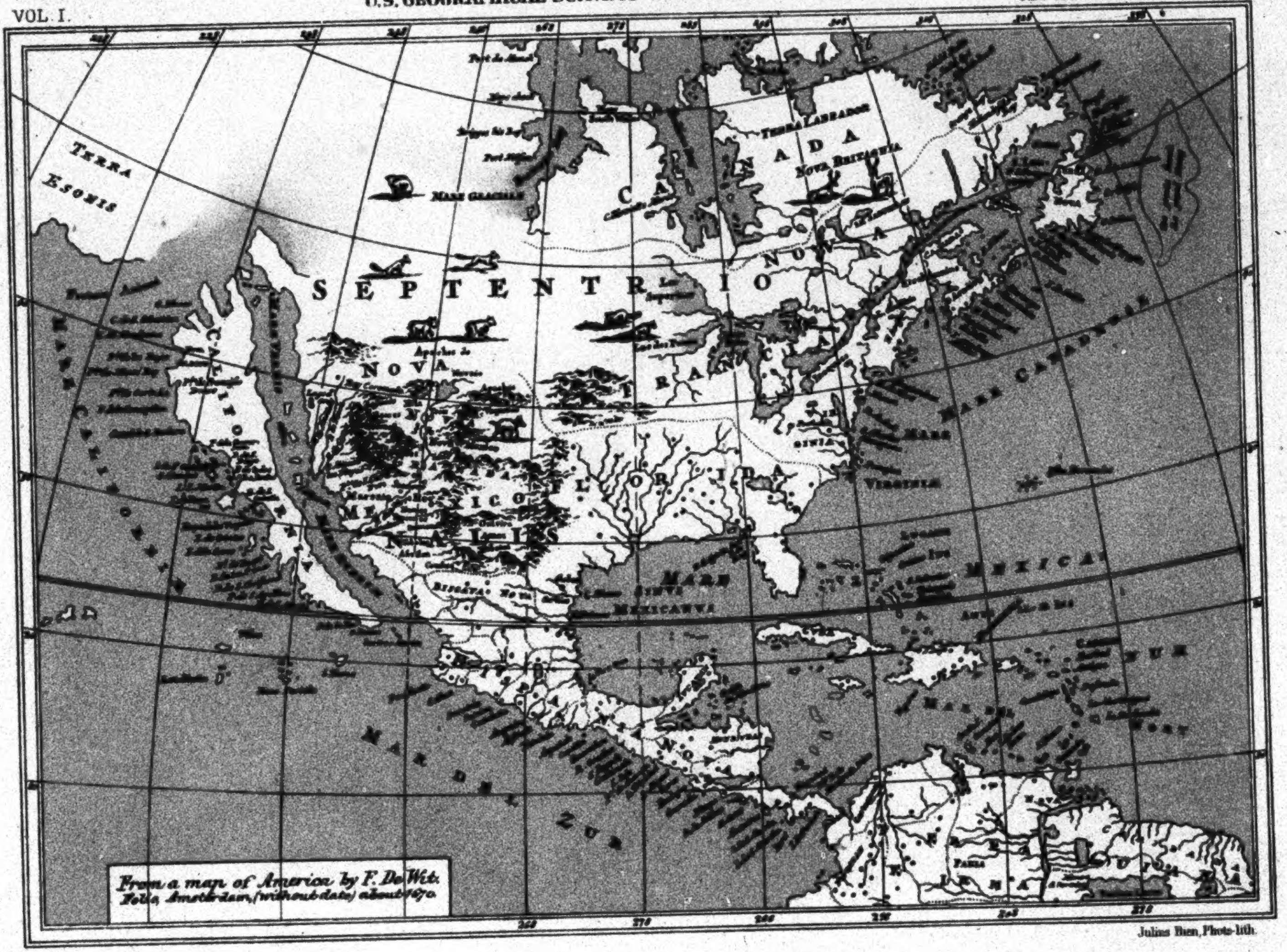
his map he represents this region as unknown. That there was no water was only discovered by Captains James and Fox, who about 1630 sailed along those coasts of Hudson's Bay.

"California," so Purchas says further, has been believed until now erroneously to be a continent. "But it is now found to be an island, stretching as far as 42° north latitude, as may appear in *a map of that island which was brought to London out of Holland.*" The Californian Gulf is, consequently, after him, no gulf, but a long strait, which he represents as certainly going as far as 42° north latitude, and which *may* go still farther north and *may* be connected with Hudson's Bay.

Hudson's Bay is stretched out two degrees too far to the south. He gives to the northern part of the Pacific Ocean the name "*Oceanus Japonicus*" (the Japanese Ocean).

His map is, perhaps, the first printed map on which we find the name of "Nova Brittannia" (New Britain) for Labrador.

All the Spanish and other foreign names on the map are so very corrupted that sometimes they even can not be recognized. (See Winsor-Kohl maps, p. 21, No. 100; also p. 53, No. 284, A. D. 1625.)


TERRA ESONIS
MARE GLACIALE
CANADA
TERRA LABRADOR
NOVA BRITANNIA
SEPTENTRIO
NOVA FRANCIA
NOVA MEXICO
FLORIDA
VIRGINIA
MARE CANADENSE
MARE MEXICANUM
MARE DEL ZUR
MARE CALIFORNIA
CALIFORNIA

From a map of America by F. De Wit. Folio, Amsterdam, (without date) about 1670.

Julius Bien, Photo-lith.

FROM A MAP OF AMERICA BY F. DE WIT. FOLIO. AMST. (WITHOUT DATE—ABOUT 1670).*

Shows California as an island. The Arctic Ocean, although already entered, is not delineated.

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* The first example of De Wit's imprint appeared about 1675, at Amsterdam, with a printed index calling for 102 maps. S. Wolfgang, 1660, published an atlas, with maps by Blaeu, Visscher, De Wit, and others. Other atlases have the name of F. de Wit. The Blaeu establishment was burned in 1672 and most of the plates were lost. Those saved passed into the hands of De Wit. (P. 376, vol. IV, Narr. and Crit. Hist. of America.)

FROM MAP OF NORTH AMERICA BY JOHN SENEX,* F. R. S., LONDON, 1710.

California is still shown as an island, although Father Kuhn in 1701–3 had already again demonstrated the peninsularity of Lower California.

See Winsor, Harvard College Library, Bulletin No. 19. Kohl maps, p. 22, 1710. "John Senex's map of North America, of which there is a reproduction in David Mill's *Report on the Boundaries of the Province of Ontario, Toronto*, 1873."

The above map purports to give corrections up to date, from the observations communicated to the Royal Society at London and the Royal Academy at Paris.

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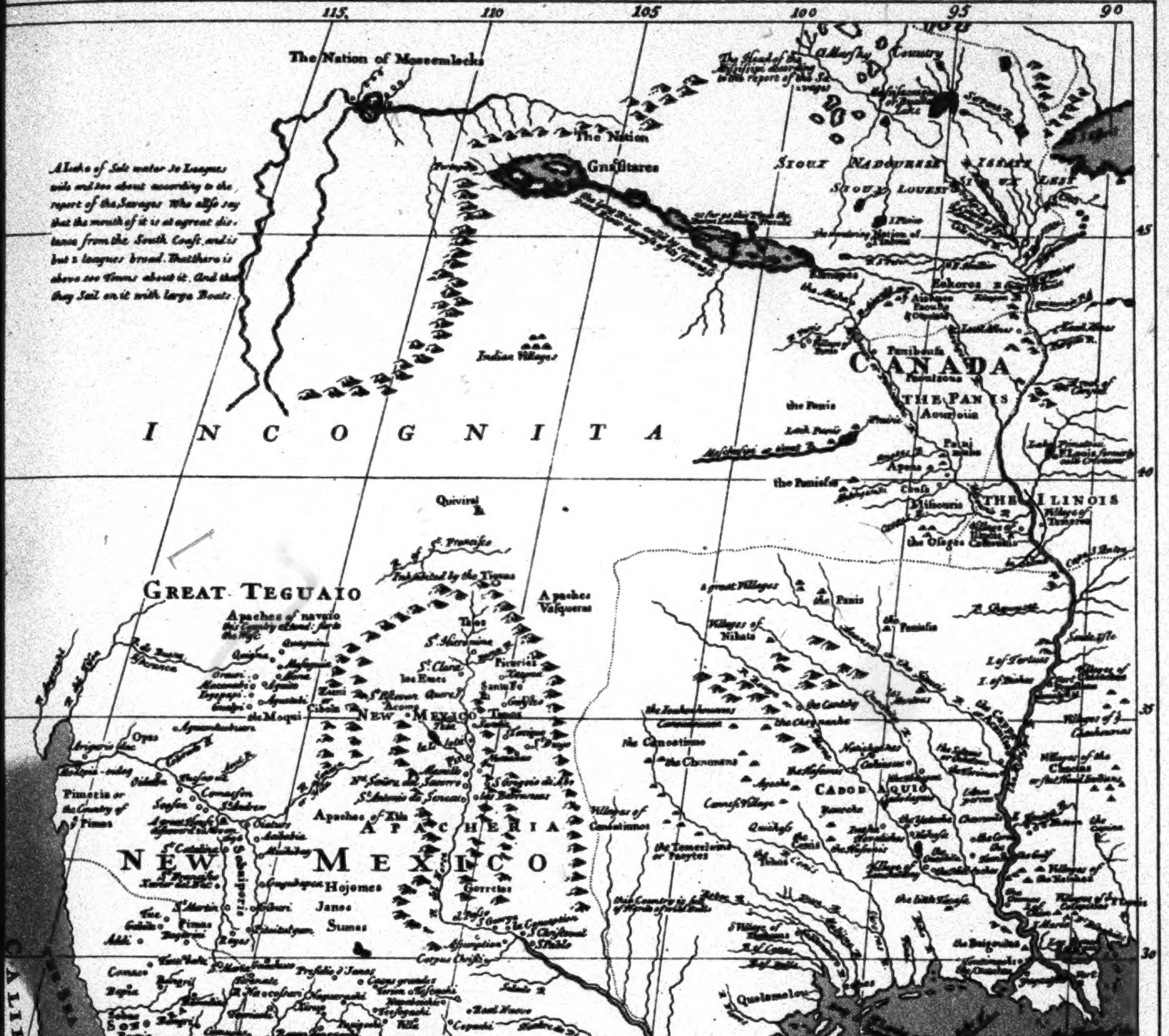
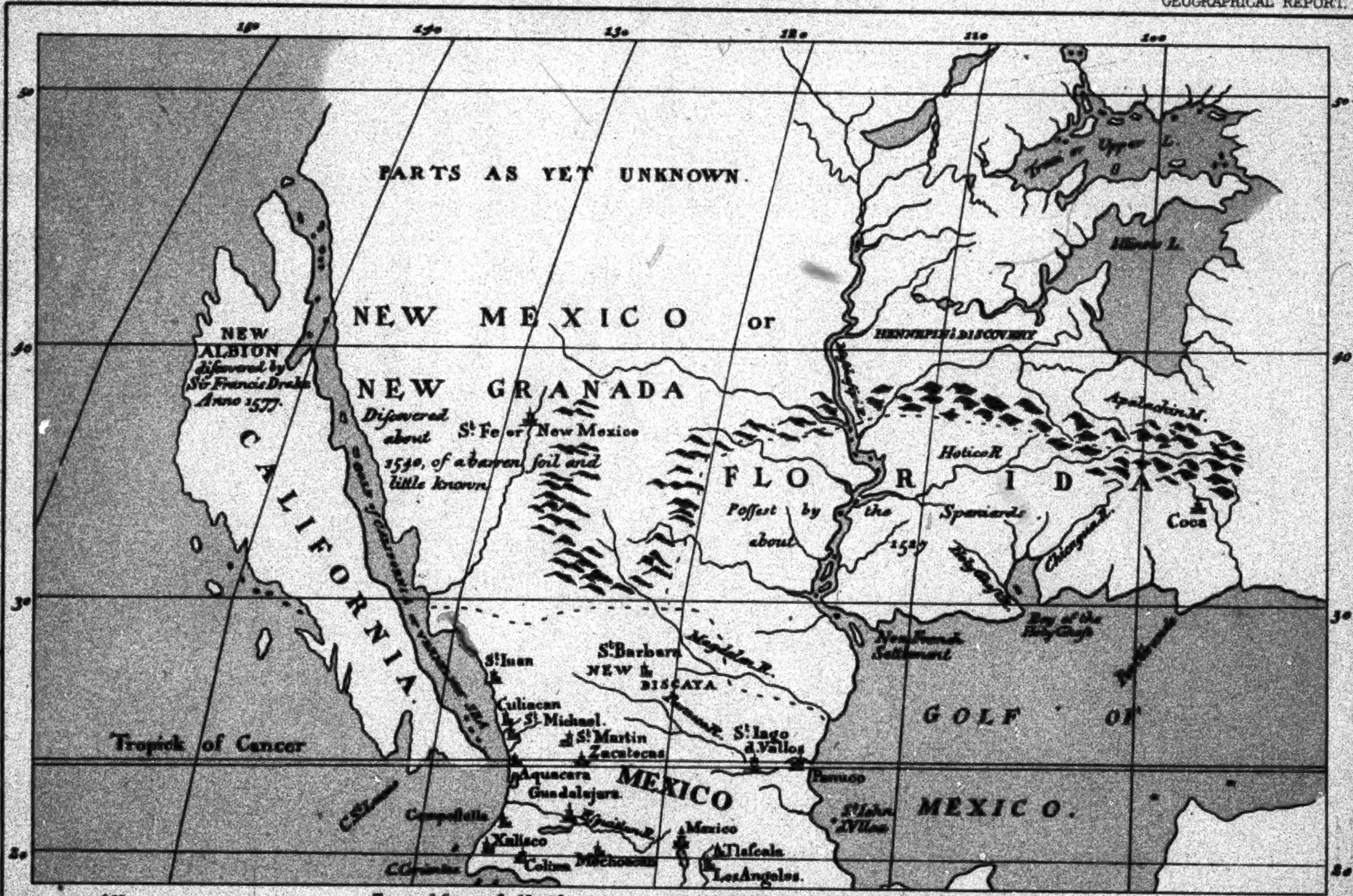
* It appears that later the above author rejected the Lahontan story of the "Long River."


115
110
105
100
95
90
45
40
35
30
25
The Nation of Moozemlecks
A Lake of Salt water 30 Leagues wide and 200 about according to the report of the Savages Who alſo say that the mouth of it is at a great distance from the South Coaſt, and is but 2 leagues broad. That there is above 100 Towns about it. And that they Sail on it with large Boats.
The Nation
Gnasitares
Sioux
Nadouesse
Sioux Louest
Indian Villages
CANADA
the Panis
The Panis
Missouris
the Osages
THE ILINOIS
INCOGNITA
Quivira
Inhabited by the Tiguas
Apaches Vaquaeros
GREAT TEGUAIO
Apaches of navaio
Taos
S. Clara
Santa Fe
NEW MEXICO
the Moqui
Cibola
Apaches of Xila
APACHERIA
NEW MEXICO
Pimeria or the Country of y Pimas
Casa grande
Hojomes
Janos
Sumes
Corpus Christi
the Canecimes
the Chouman
CADODAQUIO
Quelamelou
Lake of S. Joseph
CINALOA
CULIACAN
NEW BISCAY
NEW LEON
GUASTECA
PANUCO
ZACATECAS
CALIFORNIA
THE SEA OF CALIFORNIA
GULF OF MEXICO

From Map of North America by John Senex, F.R.S. 1710 (Reduced.)

Julius Bien, Photo-lith.


PARTS AS YET UNKNOWN.
NEW MEXICO or
NEW GRANADA
Discovered about 1540, of a barren soil and little known
St. Fe or New Mexico
NEW ALBION
Discovered by Sr. Francis Drake Anno 1577.
CALIFORNIA
FLORIDA
Possest by the Spaniards about 1527
Hotico R.
Apalachin M.
Coca
HENNEPIN'S DISCOVERY
Upper L.
Illinois L.
Bay of the Holy Ghost
New French Settlement
St. Barbara
NEW BISCAYA
Magdalen R.
St. Iuan
Culiacan
St. Michael.
St. Martin
Zacatecas
St. Iago d. Vallos
Panuco
Aquacara
Guadalajara
MEXICO
Compostella
Xalisco
Colima
Mechoacan
Mexico
Tlascala
Los Angeles
St. John d. Ulloa
GOLF OF MEXICO.
Tropick of Cancer
C. St. Lucas
C. Corientes
50
40
30
20
150
140
130
120
110
100

From Map of North America by Edward Wells, M.A. 1722. (Reduced)

Julius Bien, Photo-lith.

FROM MAP OF NORTH AMERICA BY EDWARD WELLS, M. A., 1722.*

California is still shown as an island, and discoveries above about 45° N. lat are ignored.

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*The full title is "A new map of the most considerable plantations of the English in America." The Wells atlas of 41 maps, of which No. 39 is a part of North America, is entitled "A new sett of maps, Both of Antient and Present Geography, Edward Wells, M. A., and student of Christ-Church, Oxon."

FROM MAP OF NORTH AMERICA BY THOMAS JEFFERYS, 1782.[*]

California is shown as a peninsula. The name of New Albion is prominent. Explorations had reached as high as 68° N. lat.

The above map purports to be a true delineation of North America with the Atlantic and Pacific Oceans, and the nearest coasts of Europe and Asia, with the tracks of the latest circumnavigators and other discoveries; also the coasts of California and New Albion. The Russian discoveries between Asia and America taken from the map published at St. Petersburg in 1774, by Mr. J. Von Stablin, secretary to the Imperial Academy.[†]

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[*] Jeffery's American Atlas being a description of the whole continent of America, engraved on forty-eight copper plates, folio, was published in London 1775.

[†] For the published authorities on maps of North America and its west coast during this period the following may be cited:

Santarem: Cosmography and Cartography of the Middle Ages. 3 vols. 8°. Paris, 1849.

Lelewel: Géographie du Moyen Âge, Bruxelles, 1852. 3 vols. 8° and atlas.

D'Avezac: History of the Projection of Geographical Maps.

Uricoechea: Mapoteca Columbiana. London, 1860. [The British Museum has the author's copy, with additional and voluminous notes in MS. compiled subsequent to 1860, and prior to his death.]

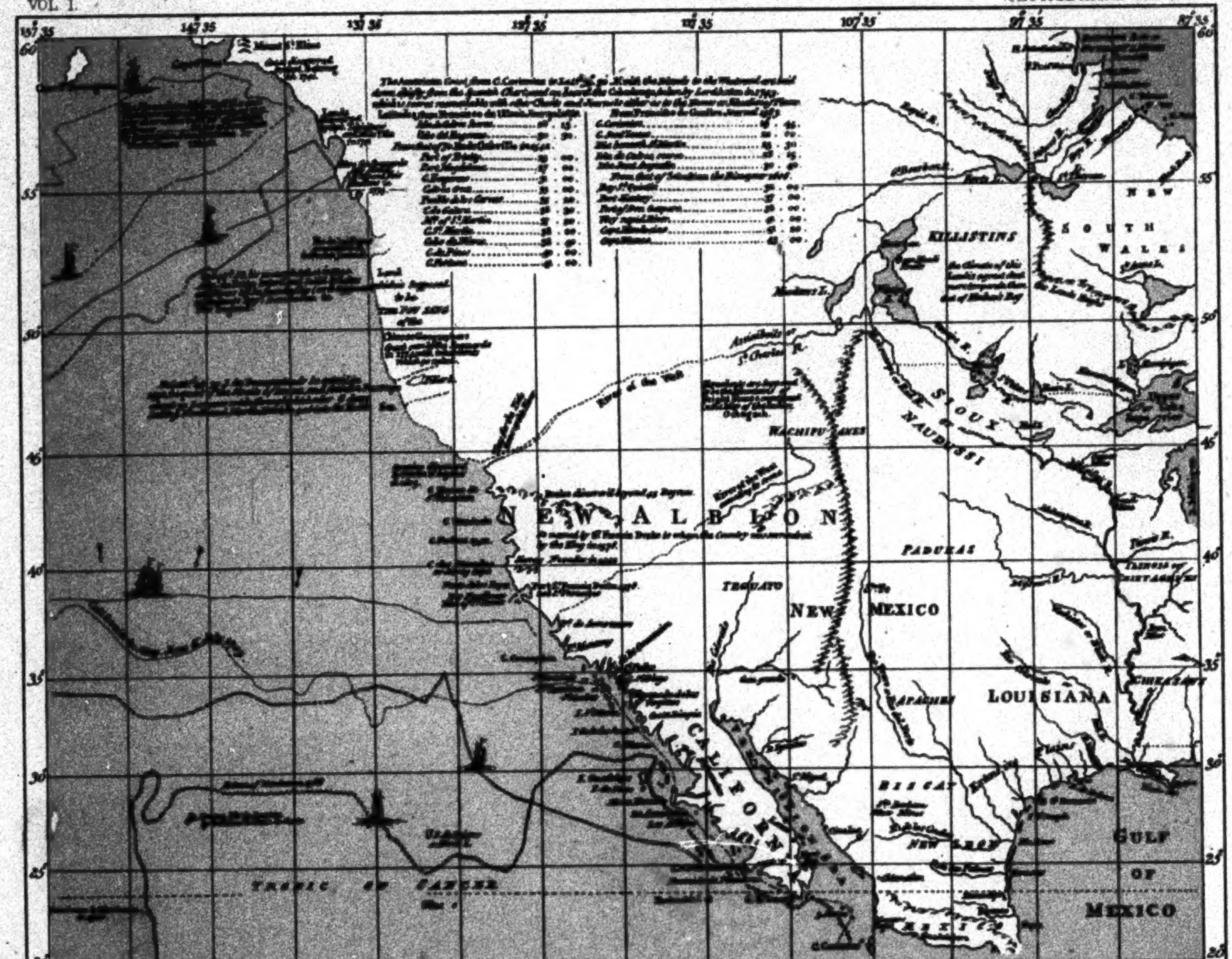
British Museum: Catalogue of Maps, etc.

Winsor: Harvard Library, No. 18. A Bibliography of Ptolemy's Geography.

Winsor: Harvard Library No. 19. The Kohl collection of early maps.

Daly: Bulletin, Am. Geog. Soc., No. 1, 1879. The Early History of Cartography.

Narrative and Critical History of America: Vol. IV, General Atlases and Charts of the 16th and 17th centuries, pp. 369–374.


157 35
147 35
137 35
127 35
117 35
107 35
97 35
87 35
60
55
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25
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NEW SOUTH WALES
KILLISTINS
SIOUX NAUDESSI
NEW ALBION
PADUCAS
TEGUAYO
NEW MEXICO
APACHES
LOUISIANA
CALIFORNIA
BISCAY
NEW LEON
MEXICO
GULF OF MEXICO
TROPIC OF CANCER

From Map of North America by Thomas Jefferys, 1782 (Reduced)

Julius Bien, Photo lith.

PART II.

EPITOME OF WARREN'S MEMOIR.—1800–1857.

MEMOIR

* * * * * * *

GIVING

A BRIEF ACCOUNT OF EACH OF THE ENGLISH EXPEDITIONS SINCE A. D. 1800.

* * * * * * *

BY

LIEUT. GOUVERNEUR K. WARREN,

CORPS OF TOPOGRAPHICAL ENGINEERS, U. S. A.

1859.

LETTER TO THE SECRETARY OF WAR.

WAR DEPARTMENT, OFFICE OF EXPLORATIONS AND SURVEYS,
Washington, D. C., March 2, 1858.

SIR: I transmit herewith a report from Lieut. G. K. Warren, Topographical Engineers, exhibiting the data and authorities from which was compiled the map of United States territory between the Mississippi River and the Pacific Ocean, intended to illustrate the reports upon the Pacific railroad explorations.

It contains a brief account of all the explorations of our territory west of the Mississippi River of approved authority, which will be not only valuable to the officers of the corps, but, it is thought, interesting to the public.

The laborious task of compiling the map and preparing the report has been performed by Lieutenant Warren while occupied with other duties of an onerous character. The more carefully his work is examined the more apparent will be the industry, care, and sound judgment with which it has been executed.

Very respectfully, your obedient servant,

A. A. HUMPHEYS,
Captain Topographical Engineers, in charge.

Hon. J. B. FLOYD,
Secretary of War, Washington, D. C.

LETTER TO CAPT. A. A. HUMPHREYS, TOPOGRAPHICAL ENGINEERS.

WAR DEPARTMENT, OFFICE OF EXPLORATIONS AND SURVEYS,
Washington, D. C., March 1, 1858.

SIR: * * * This memoir is a brief account of the numerous explorations made in our territory west of the Mississippi River, and I hope may prove valuable to those seeking information with a view to developing the resources of this vast region, as well as interesting to those studying the progress of geographical discovery. The work has been in progress during the past four years; but other public duties have absorbed the greater part of my time, which must be my excuse for its defects. * * *

I have the honor to be, very respectfully, your obedient servant,

G. K. WARREN,
First Lieutenant, Topographical Engineers.

Capt. A. A. HUMPHREYS,
Corps of Topographical Engineers, in charge of
Office of Explorations and Surveys.

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INTRODUCTORY REMARKS.

* * * * * * * * *

Before detailing the manner in which the compilation has been made, I have therefore thought it desirable to give a brief account of each of the different explorations, * * * the methods employed in observing, the maps prepared, etc., in order of date.

By this undertaking I hope to promote the consultation of the original reports and maps, by pointing out to each investigator those works which probably contain information about the region of country especially interesting to himself. As a general rule, I shall confine myself to the explorations made in the territory of the United States.

The maps of the old Spanish and French navigators and explorers who visited the Mississippi, the Gulf of Mexico, and the shores of the Pacific, and who often examined portions of the interior, have nearly all been replaced within our territory by more accurate determinations of our own. They have, therefore, little practical value in this connection, and will not be specially noticed. An almost complete account of Spanish discoveries in New Mexico prior to 1811 can be found in Baron Humboldt's New Spain. The subject is still further discussed in Lieut. James Abert's report of reconnaissances in New Mexico in 1846, Capt. A. W. Whipple's report of survey of railroad route near the 35th parallel, and elsewhere.

A valuable history of the progress of early discoveries on the western coast of North America can be seen in a French work by M. Duflot de Mofras, published in 1844, and also in Mr. Robert Greenhow's book on Oregon and California, published in 1845. This last work is accompanied by a map "of the western and middle portions of North America," compiled by Mr. Greenhow.

* * * * * * * * *

The first exploration which seems to require a detailed notice is that of Captains Lewis and Clarke, U. S. A., directed by President Jefferson in 1803

* * * * * * * * *

As the explorations are mentioned in order of date, the various examinations in the same region, or along the same route or river, are necessarily separated. To avoid the difficulty which this arrangement presents in making a prompt reference to all the sources of information of any one subject, an index has been prepared which will be found at the end of this memoir. The political and military divisions of the country are taken in the index as they appear on the first edition of the map, which was correct at the date of this report.

CHAPTER I.

EXPLORATIONS FROM A. D. 1800 TO A. D. 1832.

Captains Lewis and Clarke, U. S. A., 1804-'5-'6.—Major Pike, U. S. A., 1805-'6.—Humboldt's New Spain, 1811.—Rector, C. E., and Roberdeau, T. E., map, 1818.—Major Long, T. E., first expedition, 1819-'20.—Major Long, T. E., second expedition, 1823.—J. C. Brown, C. E., survey, 1825-'26-'27.—R. Richardson, C. E., survey, 1826.—Northwest boundary Commission, 1828.—British Admiralty charts, 1828.—Lieutenant Hardy, R. N., Explorations Gulf of California, 1825-'26-'27-'28.—Ross Cox's "Adventures on the Columbia," 1832.—Lieutenant Allen, U. S. A., reconnaissance of the source of the Mississippi, 1832.—Schoolcraft's Narrative, 1832.—Finley's Map of North America, 1826.

EXPLORATIONS OF CAPT. MERIWETHER LEWIS, U. S. A., AND CAPT. WILLIAM CLARKE, U. S. A., IN 1804-'5-'6.

The narrative I have consulted most particularly is entitled "*Travels to the Source of the Missouri River and across the American Continent to the Pacific Ocean, performed by order of the Government of the United States in the years* 1804, 1805, *and* 1806. *By Captains Lewis and Clarke; published from the official report, and illustrated by a map of the route and other maps. London: Printed for Longman, Hurst, Rees, Orme, & Brown, Paternoster Row.*—1814." This book consists of one volume quarto, illustrated by a map on a scale of seventy miles to an inch, showing the country from Lake Superior and the Mississippi to the Pacific Ocean, between the 39th and 49th parallels. The other maps are enlarged plans of certain important localities. Another and more common edition, published by the same parties in 1817, is composed of 3 volumes 8vo, with a map on a scale of about eighty miles to an inch.

An account of the expedition was also published in 1808, by Patrick Gass, a sergeant on the exploration; it contains some particulars not noticed in the official narrative.

An abridged edition, prepared by Archibald M. Vickar, was published in two volumes in Harper's Family Library Series, in 18—. The map accompanying this edition has one glaring error, in placing a high range of mountains ranging east and west between the Missouri and Yellowstone Rivers.

* * * * * * * * *

THE JEFFERSON PRODROME AND THE APOCRYPHA.*

On the 19th of February, 1806, the expedition being then still in progress, President Jefferson addressed to Congress a communication entitled as follows:

[1806.] *Message | from the | President of the United States | communicating | Discoveries | made in exploring | the Missouri, Red River and Washita, | by | Captains Lewis and Clarke, Doctor Sibley, | and Mr. Dunbar; | with | a Statistical Account | of the | Countries adjacent. | — | February 19, 1806. | Read, and ordered to lie on the table. | — | City of Washington: | A. & G. Way, printers. | . . . | 1806.*

8vo. *pp.* 1–171, 3 *l.* (*State Papers.*)

[1806.] *Message | from the | President of the United States, | communicating | Discoveries | made in exploring the | Missouri, Red River and Washita, | by | Captains Lewis and Clarke, Doctor Sibley | and Mr. Dunbar; | with | a Statistical Account | of the | Countries adjacent. | — | Read in Congress, February 19, 1806. | — | New-York: | Printed by Hopkins and Seymour, | and sold by G. F. Hopkins, No. 118, Pearl-street. | — | 1806.*

One vol. 8vo, pp. 128 + 1 folded l. not paged.

[1807.] *Travels | in the | Interior Parts of America; | communicating | Discoveries | made in Exploring | the Missouri, Red River and Washita, | by | Captains Lewis and Clark, | Doctor Sibley, | and | Mr. Dunbar; | with | a statistical account | of the | Countries adjacent. | — | As laid before the Senate, | by the | President of the United States. | In February, 1806 | and never before published in Great Britain | — | London: | Printed for Richard Phillips, 6, Bridge street, | Blackfriars, | By J. G. Barnard, 57, Snow Hill. | — | 1807.*

8vo, pp. 1–116, with a folding table. Forming part, separately paged, of Vol. VI of Phillip's "Collection of Modern and Contemporary Voyages," &c.

[1809.] *"The Travels of Capts Lewis and Clarke, from St. Louis, by way of the Missouri and Columbia rivers, to the Pacific Ocean; performed in the years 1804, 1805, and 1806, by order of the government of the United States, containing delineations of the manners, customs, religion, &c. of the Indians, compiled from Various Authentic Sources, and original Documents, and a Summary of the Statistical View of the Indian Nations, from the official communication of Meriwether Lewis. Illustrated with a Map of the Country, inhabited by the Western Tribes of Indians. 8vo, pp. ix and 309. London, 1809."*

[1809.] *The | Travels | of | Capts. Lewis & Clarke, | by order of the | Government of the United States, | performed in the years 1804, 1805, & 1806, | being upwards of three thousand miles, from | St. Louis, by way of the Missouri, and | Columbia Rivers, to the | Pacific Ocean: | Containing an Account of the Indian Tribes, who inhabit | the Western part of the Continent unexplored, | and unknown before. | With copious delineations of the manners, cus- | toms, religion, &c. of the Indians. | Compiled | From various authentic sources, and Documents. | To which is subjoined, | A Summary of the Statistical View of the Indian | Nations, from the Official Communication of | — | Meriwether Lewis. | — | Embellished with a Map of the Country inhabited by | the Western Tribes of Indians, and five Engravings | of Indian Chiefs. | — | Philadelphia: Published by Hubbard Lester. | . . . . | 1809. | Price — 1 dollar 62½ cts. |*

One vol., 12mo, pp. i–xii, 13–300, pll. 5, map, and tail-piece (scroll and pen). (Copyright dated April 17, 1809.)

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* The subjoined titles are extracted from the admirable résumé "of the various publications relating to the travels of Lewis and Clarke," by Dr. Elliott Coues, U. S. A. For which see Bulletin No. 6 of the United States Geological and Geographical Survey of the Territories.

[1812.] *An | Interesting Account | of the | Voyagie and Travels | of | Captains Lewis and Clark, | in the years* 1804, 1805, *and* 1806. | *Giving a faithful description of the river Missouri and | its source—of the various tribes of Indians through | which they passed— | manners and customs—soil—climate | —commerce—gold and silver mines—animal and vege- | table productions interspersed with very enter- | taining anecdotes, and a variety of other useful and | pleasing information remarkably calculated to de- | light and instruct the readers—to which is added a | complete dictionary of the Indian tongue. | By William Fisher, Esq. | — | Baltimore: | Printed by Anthony Miltenberger, For the purchasers.* | 1812.

One vol., 12mo, 2 *portraits, pp. v–xv,* 16–326.

[1813.] *An | Interesting Account | of the | Voyages and Travels | of | Captains Lewis and Clarke, | in the years* 1804–5, *&* 6. | *Giving a faithful description of the river Missouri and | its source—of the various tribes of Indians through | which they passed—manners and customs—soil | —climate—commerce—gold and silver | mines—animal and vegetable | productions. | Interspersed | With very entertaining anecdotes, and a variety of | other useful and pleasing information, re- | markably calculated to delight and | instruct the readers. | To which is added | A complete Dictionary of the Indian tongue | — | by William Fisher, Esq. | — | Baltimore: | printed and published by P. Mauro, | Nº.* 10, *North Howard St.* | 1813.

One vol., 12mo, *portraits?" pp. iii–xii,* 13–262, *with* 3 *full-page wood-cuts.*

[1840.] *The | Journal | of | Lewis and Clarke, | to the Mouth of the Columbia River | beyond the Rocky Mountains. | In the years* 1804–5, *&* 6. | *Giving a faithful description of the River Missouri | and its source—of the various tribes of Indians | through which they passed—manners and cus- | toms—soil—climate—commerce—gold and | silver mines—animal and vegetable | productions, &c. | New Edition, with Notes. | Revised, corrected, and illustrated with numerous | wood cuts. | To which is added | a complete dictionary of the Indian tongue. | — | Dayton, O. | Published and sold by B. F. Ells, | John Wilson, Printer* | . . . . | 1840.

One vol., 16mo, *pp. i–xii,* 13–240, *portraits of Lewis and of Clarke, and* 14 *other full-page wood-cuts.*

[1807.] *A Journal | of the | Voyages and Travels | of a Corps of Discovery, | under the command of Capt. Lewis and Capt. | Clarke, of the Army of the United States, | from | the mouth of the River Missouri through the | interior parts of North America | to the Pacific Ocean, | during the years* 1804, 1805, *&* 1806. | *Containing | An authentic relation of the most interesting transactions | during the expedition,—A description of the country,— | And an account of its inhabitants, soil, climate, curiosities | and vegetable and animal productions. | — | By Patrick Gass, | one of the persons employed on the expedition. | — | With geographical and explanatory notes | by the publisher. | — | [Copy-right secured according to law.] | Pittsburgh, | printed by Zadok Cramer, | for David M'Keehan, Publisher and | proprietor.* . . . . 1807. |

One vol., 12mo, *pp. i–viii,* 9–262. (*No illustrations.*)

[1810.] *A | Journal | of the | Voyages and Travels | of a Corps of Discovery, | under the command of Capt. Lewis and Capt. | Clarke, of the Army of the United States, | from | the mouth of the River Missouri through the | interior parts of North America, | to the Pacific Ocean, | During the years* 1804, 1805. *and* 1806. | *Containing | an authentic relation of the most interesting transac- | tions during the expedition,—A description of | the country,—And an account of its inhabi- | tants, soil, climate, curiosities, and ve- | getable and animal productions. | — | By Patrick Gass, | one of the persons employed in the expedition. | — | With | geographical and explanatory notes. | — | [Copy-right secured according to Law.] | — | Philadelphia: | Printed for Mathew Carey, | No.* 122, *Market-street.* | — | 1810.

One vol., 12mo, *pp. i–viii,* 9–262, *with* 6 *full-page wood-cuts.*

[1810.] "*Voyages des capitaines Lewis et Clarke, depuis l'embouchure du Missouri jusqu'à l'entrée de la Colombia, dans l'Océan Pacifique, fait dans les années* 1805–06, *par ordre du gouvernement des États-Unis, contenant le Journal des événements les plus remarquables du voyage, la description des habitants, du sol, les productions animales et végétables, etc ; trad. en français par A.-J.-N. L.* (*Lallemant*). *Paris, A. Bertrand,* 1810, *in-8, avec carte,* 6 *fr.*"

[1814.] *History* | *of* | *The Expedition* | *under the command of* | *Captains Lewis and Clark,* | *to* | *the sources of the Missouri,* | *thence* | *across the Rocky Mountains* | *and down the* | *River Columbia to the Pacific Ocean.* | *Performed during the years* 1804–5–6. | *By order of the* | *Government of the United States.* | *Prepared for the press* | *by Paul Allen, Esquire.* | *In two volumes.* | *Vol. I[II].* | *Philadelphia:* | *Published by Bradford and Inskeep; and* | *Abm. H. Inskeep, Newyork.* | *J. Maxwell, Printer.* | 1814.

Two vols., 8vo. Vol. I, pp. i–xxviii, 1–470, *maps. Vol. II, pp. i–ix,* 1–522, *maps.* (> *Vol. II, Chap. VII,* "*A general description of the beasts, birds, and plants, &c., found by the party in this expedition,*" pp. 148–201.)

[1815.] *Travels* | *to the source of* | *the Missouri River* | *and across the* | *American Continent* | *to* | *the Pacific Ocean.* | *Performed by order of* | *the Government of the United States,* | *in the years* 1804, 1805, *and* 1806. | — | *By Captains Lewis and Clarke.* | — | *Published from the Official Report,* | *and illustrated by a map of the route,* | *and other maps.* | — | *A new edition, in three volumes.* | *Vol. I,* [*II, III.*] | — | *London:* | *Printed for Longman, Hurst, Rees, Orme, and Brown.* | *Paternoster-Row.* | 1815.

Three vols., 8vo. *Vol. I, pp. i–xxvi,* 1 *l. not paged,* 1–411, *maps* 3. *Vol. II, pp. i–xii,* 1–434, *maps* 3. *Vol. III, pp. i–xii,* 1–394. (> *Vol. III, Chap. XXIV,* "*A general description of the beasts, birds, plants, &c., found by the party in this expedition,*" pp. 1–73.)

[1815.] "(*Lewis und Clarke.*) *Tagebuch e. Entdeckungsreise durch Nord.-Amerika in d. Jahren* 1804–6. *Aus d. Engl. v. Weyland. Mit* 1 *Karte.*" < *Neue Bibliothek der wichtigsten Beschreibungen, u. s. w.* (*Weimar, gr.* 8*vo.*) *Bd. I,* 1815.

[1816–'18.] *Reize* | *naar* | *de Bronnen van den Missouri,* | *en door het vaste land van America* | *naar de Zuidzee.* | *Gedaan op last van de Regering der Vereenigde Staten van America,* | *in de jaren* 1804, 1805 *en* 1806. | *Door de Kapiteins* | *Lewis en Clarke.* | *Met eene Kaart.* | — | *Uit het Engelsch vertaald door* | *N. G. Van Kampen.* | — | *Eerste* [*tweede, derde en Laatste*] *Deel.* | * | *Te Dordrecht,* | *Bij A. Blussé & Zoon* | 1816. [1817, 1818].

Three vols. 8*vo. Vol. I,* 1816, *pp. i–xxxii,* 1–398, *map. Vol. II,* 1817, *pp. i–viii,* 1–390. *Vol. III,* 1818, *pp. i–xii,* 1–335.

[1842–'75.] *History* | *of* | *the Expedition* | *under the command of* | *Captains Lewis and Clarke,* | *to* | *the sources of the Missouri, thence across the Rocky* | *Mountains, and down the River Columbia to the* | *Pacific ocean; performed during the* | *years* 1804, 1805, 1806, | *by order of the* | *Government of the United States.* | *Prepared for the press* | *by Paul Allen, Esq.* | *Revised and abridged by the omission of unimportant de-* | *-tails, with an introduction and notes,* | *by Archibald M'Vickar.* | *In two volumes.* | *Vol. I.* [*II.*] | *New York:* | *Harper & Brothers, Publishers,* | *Franklin Square.* | 1868.

Two vols. 18*mo, some of the issues forming part of Harpers' series,* "*The Family Library,*" *Vol. I, pp. i–vi, i*–v*, vii–li,* 53–371, 3 *maps. Vol. II, pp. i–x,* 11–395, 3 *maps.* (> *Vol. II, Appendix,* "*Further enumeration and description of the Quadrupeds, Birds, Fishes, and Plants noticed during the Expedition,*" pp. 339–378.)

* * * * * * * * *

These explorers began to ascend the Missouri River in keel boats, cordeled by hand, in 1804. They were provided with compasses for determining their courses, and with chronometers, sextants, and artificial horizons for obtaining latitudes and longitudes. They spent the winter of 1804 and 1805 at Fort Mandan, opposite the existing Ree village, or Fort Clarke. The next season, having ascended the Missouri to the Three Forks, and named them Jefferson, Madison, and Gallatin, and believing the first to be the main stream, they followed it to its source.

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It does not appear from the journal I have read that the explorers relied much upon determinations for longitudes. That of the mouth of the Platte was taken by them half a degree too far west; that of the mouth of the Yellowstone accords well with the best recent determinations; that of the mouth of the Columbia was taken one degree too far west. The place which they mention as the extreme navigable point of the Missouri is placed by their observations on latitude 43° 30′, while the most southern point on Jefferson Fork is, according to Governor Stevens's map, in about latitude 44° 30′; thus showing a considerable discrepancy. Most of the routes and rivers they examined have been re-explored, the only exceptions being the sources of Salmon River, the Missouri River from the Gate of the Mountains to its source, and the Yellowstone from the point where Captain Clarke struck it to the mouth of Powder River. The tests to which the maps of this exploration have been subjected prove them to have been carefully made and with great accuracy, considering the means and circumstances of the party.

The original map represents the different ridges of the Rocky Mountains with a general northwest trend from the Black Hills westward, and it is neither responsible for the error of representing those north of the Platte with a northeast trend nor for the false indication of a range of mountains running east and west between the Yellowstone and Missouri. Deceived by the size of the Wallamath at its mouth, these explorers supposed it to be a stream of great length, and represented it on their map as heading to the southwest in the vicinity of what is now known to be the Great Salt Lake. The names they gave to the rivers have been generally adopted, although a little confusion exists about some of the smaller ones. Captain Lewis's melancholy death occurred before the completion of the narrative, thus devolving the whole labor of the report upon his able associate, Captain Clarke. Several editions of the work have appeared, differing somewhat from each other; and thus, no doubt, has arisen the misunderstanding now existing concerning the names of places.

EXPLORATIONS OF MAJOR Z. M. PIKE, U. S. A., 1805-'6-'7.

The narrative I have consulted is entitled "*An Account of Expeditions to the Sources of the Mississippi, and through the western parts of Louisiana, to the Sources of the Arkansas and Pierrejaun Rivers, performed by order of the Government of the United States, during the years* 1805, '6, *and* '7; *and a Tour through the interior parts of New Spain, when conducted through these provinces by order of the Captain General, in* 1807. *By Major Z. M. Pike; illustrated by maps and charts. Published by C. & A. Conrad & Co., Philadelphia. John Binus, printer.*—1810." Accompanying it is a map of the Mississippi River from the mouth of the Missouri River to Leech Lake, on a scale of about 25 miles to one inch; a map, in two sheets, on a scale of about 40 miles to one inch, showing the supposed positions of the Platte, Arkansas, and Red Rivers, from their mouths to their sources; and a map of New Spain, in two sheets, on a scale of about 75 miles to an inch.

In 1805 and 1806 Lieutenant Pike,* in his expedition to the sources of the Mississippi, ascended the stream from the mouth of the Missouri to what is called Upper Red Cedar Lake (since named Cass Lake), and examined Turtle River, an affluent of this to its sources. He also examined Leech Lake and Leech River to its junction with the Mississippi. His map of the river gives its general direction with considerable accuracy, and is the more creditable to him, since, in his own language, "in the execution of this voyage I had no gentlemen to aid me, and I literally performed the duties (as far as my limited abilities permitted) of astronomer, commanding officer, clerk, spy, guide, and hunter."

Lieutenant Pike's second expedition was to the sources of the Arkansas, with the intention of passing thence south to those of Red River of Louisiana, and descending this stream to Natchitoches. He was accompanied by Lieut. James B. Wilkinson, U. S. A., and Dr. J. H. Robinson, M. D., and was provided with a sextant, chronometer, and compasses.

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Nearly every part of the country traversed by Lieutenant Pike has since been explored by parties better provided with instruments, and his determinations are now replaced by others more accurate.

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*Major Pike was a lieutenant while making both of the explorations noticed here, and was promoted after his return.

Red River, the discovery of whose sources was one of the main objects of Major Pike's expedition, was examined in 1806 by a party under Captain Sparks from the mouth as far up as the Spanish border. Here he was met by a Spanish force very much superior to his in numbers, and prevented from going further.

At this time the boundary between Louisiana and New Spain was not definitely agreed upon, and the Americans and Spaniards each maintained troops near the border to prevent the incursions of the opposite party. Burr's schemes were also agitating the public mind, and probably increased the suspicions of the governments of both nations.

* * * * * * * * *

HUMBOLDT'S NEW SPAIN, 1811.

The edition of this work, which I have consulted, is entitled "*Political Essay on the Kingdom of New Spain, containing researches relative to the geography of Mexico; the extent of its surface, and its political division into intendancies; the physical aspect of the country; the population; the state of agriculture and manufacturing and commercial industry; the canals projected between the South Sea and Atlantic Ocean; the Crown revenues; the quantity of the precious metals which have flowed from Mexico into Europe and Asia since the discovery of the New Continent; and the military defence of New Spain. By Alexander de Humboldt; with physical sections and maps, founded on astronomical observations and trigonometrical and barometrical measurements. Translated from the original French by John Black. Second edition. London: Printed for Longman, Hurst, Rees, Orme, & Brown, and H. Colburn.*—1814." It is accompanied by an original map, on a scale of 120 miles to an inch, "*of New Spain, from* 16° *to* 38° *north latitude,*" between the 94th and 114th meridian; "*reduced from the large map drawn from astronomical observations at Mexico, in the year* 1804, *by Alexander de Humboldt; and comprehends the whole of the information contained in the original map, except the heights of the mountains.*"

This work, completed by the Baron Humboldt for the Spanish Government in 1808, is almost a complete summary of all the explorations made by the Spaniards down to the date of its preparation, and is therefore of much value in showing the extent of their knowledge at that day. It shows that Father Escalante, in 1777, visited or gained information about Lake

Timpanogos (doubtless Utah Lake, which has an affluent now called by that name, and which is fresh, like the one described by him), and also Lake Salado (probably Sevier Lake), which, he says, receives the waters of the Rio de San Buenaventura, its western limits being unknown. Baron Humboldt did not entertain the idea that any large river flowed into the Pacific Ocean from the region which now composes the Territory of Utah, as was generally represented on all the English maps. His work does not, however, give any positive information about the topography and hydrography of any portion of our present territory which the explorations of our Government have not replaced by more accurate results. Still, as it has formed the basis of many classifications of the great mountain system and abounds in valuable enunciations of the true principles of hydrography and topography, no one should neglect to consult it whose scientific investigations extend to the country west of the Mississippi.

RECTOR'S AND ROBERDEAU'S COMPILED MAP, 1818.

This map is titled, "*Sketch of the western part of the continent of North America, between latitude* 35° *and* 52° *N.*," from the 87th meridian to the Pacific Ocean, on a scale of about 47 miles to an inch. "*This map, of an extent of country including more than* 20° *of latitude and* 50° *of longitude, was originally drawn under the inspection of William Rector, esquire, surveyor of the United States for the Territories of Missouri and Illinois, and was by him presented to the General Land Office, January* 21, 1818. *It is probably the most correct map of the country now extant. Signed, Josiah Meigs, General Land Office, January* 21, 1818; *Roberdeau, U. S. T. Engineers, del.*"

From the year 1807 to 1819 our country was much of the time involved in foreign difficulties, and little was done, so far as I have been able to learn, in exploring our western possessions. This map of Rector and Roberdean has, I believe, never been published.

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MAJOR S. H. LONG'S FIRST EXPEDITION, 1819 AND 1820.

"*Account of an Expedition from Pittsburg to the Rocky Mountains, performed in the years* 1819 *and* 1820, *by order of the Hon. J. C. Calhoun, Secretary of War, under the command of Major Stephen H. Long, from the notes of Major*

Long, Mr. T. Say, and other gentlemen of the exploring party: compiled by Edwin James, botanist and geologist for the expedition. In two volumes, with an atlas. Philadelphia: H. C. Carey and I. Lea, Chestnut street.—1823." This book also contains Major Long's official report. Accompanying the publication is a map, in two sheets, on a scale of 75 miles to an inch, embracing the country from the meridian of Washington to the Rocky Mountains, between the 33d and 47th parallels. The original map in the Topographical Bureau is in one sheet, on a scale of 36 miles to an inch. The same work was republished "*in three volumes in London: printed for Longman, Hurst, Rees, Orme, & Brown, Paternoster Row.*—1823."

This expedition started from Pittsburgh, Pa., early in April, 1819, on board the small steam-boat *Western Engineer*, under command of Major Long. He was assisted by Major Biddle, Lieut. J. D. Graham, U. S. A., Cadet W. H. Swift, Dr. Baldwin, Dr. Thomas Say, Mr. Jessup, Mr. T. R. Peale, and Mr. Samuel Seymour. They were provided with chronometers, sextants, telescope for observing occultations and eclipses, and with compasses. They descended the Ohio River to its mouth, ascended the Mississippi to the mouth of the Missouri, and up this river to Old Council Bluff, which was the end of their travels that season, the main body wintering there at Engineer Cantonment.

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Major Long returned to the seat of General Government during the winter, and was accompanied the next spring by Capt. John R. Bell, U. S. A., who took the place of Major Biddle, and by Dr. E. James, as botanist and geologist, in the place of Dr. Baldwin and Mr. Jessup, the former having died while ascending the Missouri River. Lieutenant Graham returned from Engineer Cantonment with the steam-boat.

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This was the third attempt by exploring parties, under the United States Government, to discover the sources of Red River. The explorations of Major Long's expedition, made in Arkansas and Missouri on their return, have been replaced by the surveys of the United States Land Office. The only portions of the route of this exploration which have not been reexamined are the trails from the Arkansas to the Canadian, and from the Great Bend of the Arkansas to Fort Gibson.

The astronomical observations by Major Long, Lieutenant Graham, and Lieutenant Swift consisted of altitudes and lunar distances by the sextant and eclipses of Jupiter's satellites, observed with a four-foot telescope. The relation of their determinations to those of subsequent parties will be discussed hereafter. Their barometers were all broken before they reached the forks of the Platte. On the map which was made by Major Long we see the Black Hills of Nebraska represented as a north and south range, differing from Lewis and Clarke's map, which gave them a northwest trend. This is the first original map which represents this range as running north.

MAJOR LONG'S EXPEDITION TO THE SOURCE OF THE ST. PETER'S RIVER.

The work I have consulted is entitled "*Travels in the Interior of North America, with the particulars of an Expedition to the Lakes, and the source of the St. Peter's river. By Messrs. Long, Keating, and Colhoun; in two volumes. London: Printed for G. B. Whittaker, Ave Maria lane.*—1828." It is accompanied by a map, on a scale of 35 miles to an inch, exhibiting the route of the expedition. It includes the area limited on the northeast by a line drawn from Lake Winnipeg to the east end of Lake Ontario; on the southeast by a line from Lake Ontario to Pittsburgh; on the southwest by one from Cincinnati to Rock Island, in the Mississippi; and on the northwest by one from the Mandan villages to Lake Winnipeg.

This expedition was commanded by Maj. S. H. Long, topographical engineer, who was assisted by Thomas Say, zoologist, antiquarian, and botanist; William H. Keating, mineralogist and geologist; and James C. Colhoun, astronomer, who was supplied with a sextant and pocket chronometer. Distances were estimated and courses taken by compasses. Mr. Say and Mr. Keating, by the latter of whom the published narrative was written, acted as joint literary journalists. They started from Philadelphia in April, 1823; traveled to Wheeling; thence to Columbus; thence to Fort Wayne, on the Miami River, where they obtained a few soldiers to accompany them, and thence to the southern extremity of Lake Michigan. The journey between these last two places was through a wilderness, and on reaching Chicago they found it to consist "of a few miserable huts, inhabited by a miserable race of men," though it was, "perhaps, one of the oldest settled places in the Indian country." From this point they proceeded through the unknown wilderness to Fort Crawford, or Prairie du Chien, at the junction of the Wisconsin and Mississippi Rivers. From this point one portion proceeded rapidly by land up the right bank of the Mississippi to Fort Snelling. The other part arrived there soon after by water. This place had been visited by Major Long in 1817, and its site recommended for a permanent military post, which was established in 1819.

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The astronomer, Mr. Colhoun, made numerous observations, which embraced every kind of which a sextant is capable. Our knowledge of the route has been improved by other explorers from the mouth of the St. Peter's River to the 49th parallel, but from that point to the mouth of Dog River this map is our only authority along the route explored. The Shayenne River, which Major Long supposed to be only 50 miles long, has since been shown to have a valley about 300 miles in length.

J. C. BROWN'S SURVEY OF ROAD FROM FORT OSAGE TO TAOS, 1825 1826, AND 1827.

In the Topographical Bureau there is one map, in two sheets, of this survey, on a scale of 4 miles to an inch; another on a scale of 12 miles to an inch, and a third on a scale of 4 miles to an inch, in thirty-one sections, "of the road surveyed and marked out from the western frontier of Missouri, near Fort Osage, to San Fernando de Taos, near Santa Fé, in New Mexico, by order of the Government of the United States, in the years 1825, 1826, and 1827, with accurate and minute notes and directions for the use of travelers," which begins thus: "The following pages contain a map of the road, as surveyed and marked out from the frontier of Missouri to Taos, the first settlement in the direction to Santa Fé, under the direction of Benjamin Reeves, George C. Sibley, and Thomas Mather, commissioners appointed by the President of the United States for that purpose."

This survey was made with a chain and compass, corrected by observations for latitude with a good sextant. The longitudes were referred to the meridian of Fort Osage, which was taken at 93° 51′ 03″. This road is that of the Santa Fé trail, along the divide between the Kansas and Arkansas Rivers.

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These maps, though not displaying great skill in topographical representation, were constructed from a survey more elaborate than any subsequent one over the same route. They are therefore of much value at the present time. The names now in use along the line were many of them given by this party. I am not aware that the original map and notes have ever been published.

R. RICHARDSON'S SURVEY OF ROAD FROM LITTLE ROCK TO FORT GIBSON, [illegible]

The map of this road, in the Topographical Bureau, is constructed on a scale of four miles to an inch. The survey was made, I believe, with a chain and compass, and is valuable as showing the relative longitudes of Fort Smith and Fort Gibson. It does not seem to have been used on late compilations.

NORTHWEST BOUNDARY COMMISSION, [illegible]

The commissioners appointed under the treaty of Ghent for ascertaining and establishing the north and northwestern boundary between the United States and Great Britain made a decision (June 18, 1822) at Utica, N. Y., which was published by a resolution of the United States House of Representatives in 1828. As this publication extends their labors no further west than the outlet to Lake Superior, the information and maps do not relate to the region under consideration. I believe that the surveys made under the commission were extended as far west as the Lake of the Woods, and according to these the boundary line was fixed in the second article of the Ashburton treaty. In the State Department there is a map, in five sheets, on a scale of an inch to two miles, a reduction of which was published on Nicollet's map of the hydrographical basin of the Upper Mississippi. The original maps have the following title:

> "Map of a part of certain surveys along the water communications northward of Lake Superior, commencing at the mouth of the Pigeon River and extending westward to Lake Namekan; made by order of the honorable the commissioners under the sixth and seventh articles of the treaty of Ghent.
>
> "Signed:
>
> "PETER B. PORTER, } *Commissioners.*
> "ANTH. BARCLAY, }
> "I. FERGUSON, *Surveyor.*
> "GEORGE W. WHISTLER, *U. S. Artillery,*
> "*Draughtsman and Assistant Surveyor.*"

BRITISH ADMIRALTY CHART OF LAKE SUPERIOR, [illegible]

This chart, published from reconnaissances made by Lieut. H. W. Bayfield, R. N., are, to this day, the best we have of the northern shore of Lake Superior.

LIEUTENANT HARDY, R. N.—EXAMINATION OF GULF OF CALIFORNIA, 1825, 1826, 1827, AND 1828.

Lieutenant Hardy visited the whole coast of the Gulf from Mazatlan around by the mouth of the Colorado to Loredo, in search of pearl fisheries. He did not determine any positions by astronomical observations, and his map has not been used by me.

ROSS COX.—ADVENTURES ON THE COLUMBIA RIVER.

This book is entitled "*Adventures on the Columbia River, including a Narrative of six years on the Western side of the Rocky Mountains among various tribes of Indians hitherto unknown, together with a Journey across the American Continent: By Ross Cox. Published by J. J. Harper, New York.*—1832."

The journey across the continent was made up the Columbia to one of its northern sources, crossing the Rocky Mountains at the head of the Athabasca River, near Mount Hooker, in about latitude 52° 10′ north. The book is very interesting and instructive in regard to the early operations of the fur companies.

RECONNAISSANCE OF THE SOURCES OF THE MISSISSIPPI RIVER, BY LIEUT. J. ALLEN, U. S. A., 1832.

The report of Lieutenant Allen, with map, on a scale of 5.75 miles to an inch, exhibiting the Mississippi River from Lake Pepin to its source, together with the country adjacent to his routes, is printed in Ex. Doc. No. 323, 1st session Twenty-third Congress.

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"I was not furnished with, nor could I procure at Fort Brady, any instruments by which to fix, from astronomical observations, the true geographical positions of points necessary to be known for the construction of an accurate map; and to obviate this inconvenience I had recourse to a method of tracing the whole route between the few points fixed and given by the observations of former travelers. For this purpose a compass, the only instrument I had, was placed in my canoe, where it was constantly under my eye; and as the canoe proceeded in the line of a river I carried my observations from the compass to a field-book at every bend or change of direction, thus delineating in my field-book all the bends of the river precisely as they occurred; and by establishing a scale of proportions in the lengths of the reaches I was also in this way enabled to lay down and preserve the general curve of a river with surprising accuracy, as was tested afterwards in constructing on my map the routes of rivers between known points. The distances were estimated with great pains and care, and from the combined judgment of all the gentlemen of the party. * * *

"On the portion of the Mississippi above Cass Lake, which was the least known of any part of the river and route, I bestowed on the tracing and computing of distances the most unremitted attention."

To Lieutenant Allen we are indebted for the first topographical and hydrographical delineation of the source of the Mississippi; and this, somewhat improved by Mr. Nicollet, is our authority at the present day for the Mississippi above the mouth of Swan River. Lieutenant Allen was a companion of Mr. H. R. Schoolcraft, whose labors and writings are so well known.

SCHOOLCRAFT'S NARRATIVE OF THE EXPEDITION TO THE SOURCE OF THE MISSISSIPPI IN 1832.

The title of this work is as follows: "*Narrative of an Expedition through the Upper Mississippi to Itasca Lake, the actual source of this river, embracing an exploration through the St. Croix and Burntwood (or Brule) rivers, in* 1832, *under the direction of Henry R. Schoolcraft New York: Published by Harper & Brother, No.* 82 *Cliff street.*—1834." This book is embellished by "A sketch of the sources of the Mississippi River, drawn from Lieutenant Allen's observations in 1832, to illustrate Schoolcraft's inland journey to Itasca Lake, in two sheets, on a scale of about 11 miles to an inch."

Mr. Schoolcraft's object on the expedition in 1832 was to attempt a reconciliation of the difficulties between the Chippeway and Sioux Indians. The routes he pursued were nearly those mapped by Lieutenant Allen, as already described.

In the same book is a brief account of Mr. Schoolcraft's examinations in 1831 (in connection with his duties in relation to Indian affairs) of the country between Lake Superior and the Mississippi. His route lay up the Mauvaise or Bad River to its source, and thence down the Chippeway to its mouth.

Mr. Schoolcraft had also accompanied Gen. Lewis Cass in his expedition to the sources of the Mississippi in 1820, at which time the highest point reached was the lake called Red Cedar by Pike, but since generally known as Cass Lake.

Mr. Schoolcraft published a beautiful description of this expedition, called, "*Narrative Journal of Travels from Detroit, northwest through the great chain of American Lakes, to the sources of the Mississippi river, in the year* 1820. *By Henry R. Schoolcraft. Albany: Published by E. & E. Hosford.*—1821." It is accompanied by a map on a scale of 65 miles to an inch, exhibiting the region bounded by the 1st and 21st meridians west from Washington and the 41st and 51st parallels.

The Mississippi River, whose extreme sources Messrs. Allen and Schoolcraft have the honor of first exploring, was discovered by Hernando de Soto, who reached its banks probably near Memphis in 1541. Father Marquette and Sieur Joilet first saw it in 1673. Father Hennepin visited it in 1680, and named the St. Peter's River and the Falls of St. Anthony. The mouth was discovered in 1683 by the Sieur La Salle, who sailed down the Illinois River to the Mississippi, and navigated it to the Gulf of Mexico. M. Le Sueur visited it probably as early as 1695, at which time he discovered the blue earth on the St. Peter's. In 1702 he floated two thousand pounds of this material to the mouth of the Mississippi. These statements in regard to the discovery of the Mississippi I have taken principally from Mr. Keating's narrative of Major Long's expedition to the sources of the St. Peter's River.

We are indebted to Capt. Jonathan Carver, who visited the Upper Mississippi in 1766–'68, for much of our early knowledge of the Upper Mississippi valley, although some of his statements must be received with caution. He claims to have first conceived the idea of passing from the sources of the Missouri to the Pacific Ocean. An expedition to this effect was actually fitted out by the aid of Mr. Whitworth, when the growing troubles of the colonies with the mother country led to its abandonment.

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CHAPTER II.

EXPLORATIONS FROM A. D. 1832 TO A. D. 1844.

Captain Bonneville, U. S. A., expedition, 1832 to 1836.—Discovery of Great Salt Lake and Humboldt River.—Irving's Astoria.—Lieut. E. Steen, U. S. A., map, 1835.—Topographical Bureau, map of Western Frontier, 1837.—C. Dimmock, C. E., survey, 1838.—Capt. W. Hood, T. E., memoir and map, 1839.—Topographical Bureau, map of Oregon, 1838.—Survey boundary Louisiana and Texas, 1840.—Commander Wilkes, U. S. N., map of Oregon, 1841.—Kendall's Santa Fé Expedition, 1841.—Professor Nicollet's exploration and map, 1835–'40.—Lieut. J. C. Fremont, T. E., exploration, 1842.—Capt. N. Boone, U. S. A., expedition, 1843.—Capt. J. Allen, U. S. A., expedition, 1842.—Topographical Bureau, map of Texas, 1844.—Gregg's Commerce of the Prairies, 1844.

BONNEVILLE'S EXPEDITION TO ROCKY MOUNTAINS, 1832 TO 1836.

The narrative I have perused is entitled "*The Rocky Mountains; or, Scenes, Incidents, and Adventures in the Far West; digested from the Journal of Captain B. L. E. Bonneville, of the Army of the United States, and illustrated from various other sources. By Washington Irving. In two volumes. Philadelphia: Carey, Lea & Blanchard.*—1837." This is accompanied by two maps; one on a scale of 23 miles to an inch, showing the sources of the Missouri, Yellowstone, Platte, Green, Bear, Snake, and Salmon Rivers, and a portion of Lake Bonneville (Great Salt Lake); the other, on a scale of 50 miles to an inch, giving the country from the Rocky Mountains to the Pacific, between the parallels of 38° and 49° north latitude.

Captain Bonneville's explorations were made in prosecution of the fur trade, which was his principal object, and very great accuracy in the map is not therefore to be expected. His letter of instructions, from Major-General Macomb, dated Washington, August 3, 1831, contains the following directions: "The leave of absence which you have asked, for the purpose of enabling you to carry into execution your design of exploring the country to the Rocky Mountains and beyond, * * * has been duly considered and submitted to the War Department for approval, and has been sanctioned. You are therefore authorized to be absent from the Army till October, 1833. It is understood that the Government is to be at no expense in reference to your proposed expedition, it having originated with yourself. * * * You will naturally, in preparing yourself for the expedition, provide suitable instruments."

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Having made his arrangements for the year he visited the Great Salt Lake and saw its northern portions. "To have this lake properly explored and all its secrets revealed was the grand scheme of the captain for the present year. * * * This momentous undertaking he confided to Mr. Walker, in whose experience and ability he had great confidence." "He instructed him to keep along the shores of the lake, and trap in all the streams on his route. He was also to keep a journal and minutely to record the events of his journey and everything curious or interesting, and make maps or charts of his route and of the surrounding country." No pains nor expense were spared in fitting out this party, which was composed of forty men. They had complete supplies for a year, and were to meet Captain Bonneville in the ensuing summer in the valley of Bear River, the largest tributary of Salt Lake.

This party endeavored to proceed south over the great barren salt plain lying to the west of the lake, but their sufferings became so great, and the danger of perishing so imminent, that they abandoned the proposed route and struck to the northwest for some snowy mountains in the distance. Thus they came upon Ogden's (Humboldt) River, and followed down it to the "sinks," or place where it loses itself in the sand. Continuing on they crossed the Sierra Nevada, in which they were entangled for twenty-three days, suffering very much from hunger, and finally reached the waters of the Sacramento; thence turning south they stopped at the Mission of Monterey. After a considerable sojourn the party started to return. Instead of retracing their steps through the Sierra Nevada they passed round its southern extremity, and crossing a range of low hills, found themselves in the sandy plains south of Ogden's River, where they again suffered grievously from want of water. On this journey they encountered some Mexicans, two of whom accompanied them to the rendezvous appointed by Captain Bonneville. The return route of this party probably was nearly that taken by Captain Fremont in 1842, and known as the Santa Fé trail to California. They thus traveled quite around the Great Basin system.

While this expedition was in progress Captain Bonneville made an excursion to the headwaters of the Yellowstone. Leaving Green River he moved east to the sources of the Sweetwater, so as to turn the Wind River Mountains at their southeast extremity; thence striking the head of the Popo Agie, he passed down it to Wind River, which he followed through the gap of the Little Horn Mountains, and through the Big Horn range. Below these mountains the river becomes navigable for canoes, and takes the name of the Big Horn River From this point he returned to Wind River and attempted to cross the Wind River Mountains direct to his caches on Green River. In this he was foiled by the chasms and precipices and compelled to take his former route around their southeastern extremity. From the depot he went up to the sources of Green River, crossed the mountains between its source and that of Wind River, and again returned to Green River by the Sweetwater. He then passed over the mountains to the Bear River Valley, and thence to the Port Neuf River, where he established his winter quarters.

During the winter he started to visit the Columbia, passing down the Snake River Valley, through the Grand Ronde and over the Blue Mountains to Walla-Walla. He returned to Bear River in the succeeding June. On the 3d of July, 1834, he made a second visit to the Columbia, and returned to spend the winter on Bear River. In 1835 he returned home* by way of the Platte River.

Captain Bonneville's maps, which accompany the edition of Irving's work, published by Carey, Lea & Blanchard in 1837 (the later editions generally do not give the original maps), are the first to correctly represent the hydrography of this region west of the Rocky Mountains. Although the geographical positions are not accurate, yet the existence of the great interior basins (without outlets to the ocean) of Great Salt Lake, of Mary's or Ogden's River (named afterwards Humboldt by Captain Fremont), of the Mud Lakes, and of Sevier River and Lake, *was determined* by Captain Bonneville's maps, and they proved the non-existence of the Rio Buenaventura and of other hypothetical rivers. They reduced the Wallamuth or Multonomah (Willamette) River to its proper length, and fixed approximately its source, and determined the general extent and direction of the Sacramento and San Joaquin Rivers. The map of the sources of the Yellowstone is still the best original one of that region.

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* Captain Bonneville's long-continued absence after the expiration of his leave, during which time no news was received from him at the War Department, led to his name being dropped from the Army Register. He was, however, restored, and now holds the commission of colonel of the Third Infantry.

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Colonel Benton, in his "Thirty Years' View," page 580, says of Fremont's second expedition: "He was at Fort Vancouver, guest of the hospitable Dr. McLaughlin, governor of the British Hudson Bay Fur Company, and obtained from him all possible information upon his intended line of return, faithfully given, but which proved to be disastrously erroneous in its leading and governing feature." * * * "All maps up to that time had shown this region traversed from east to west, from the base of the Rocky Mountains to the bay of San Francisco, by a great river called the *Buenaventura*, which may be translated the *good chance*. Fremont believed in it, and his plan was to reach it before the dead of winter, and then hibernate upon it."

It is evident that Colonel Benton had never seen Captain Bonneville's map, or he would not have written this paragraph.

EARLY DISCOVERIES IN THE GREAT BASIN.

The exploration of the Great Salt Lake was a favorite object with Captain Bonneville; though called Lake Bonneville by Mr. Irving, its existence was well known to the traders and trappers on his arrival in that country, as was also that of the Ogden's or Mary's River. A short account of the first discoveries in this region may not be inappropriate in this place.

In Captain Stansbury's report, page 151, he says: "The existence of a large lake of salt water, somewhere amid the wilds west of the Rocky Mountains, seems to have been known, vaguely, as long as 150 years since. As early as 1689 the Baron la Hontan * * * wrote an account of discoveries in this region, which was published in the English language in 1735." This narrative of La Hontan of his journey up "La Rivière Longue," flowing into the Mississippi from the west, has for more than a century been considered fabulous. It is spoken of even by Captain Stansbury as an "imaginative voyage up this most imaginary river," up which La Hontan claims to have sailed for six weeks without reaching the source. During this voyage he learned from four Mozeemlek slaves belonging to the Indians living on the river "that, at the distance of 150 leagues from the place he then was, their principal river empties itself into a salt lake of 300 leagues in circumference, the mouth of which is two leagues broad; that the lower part of that river is adorned with six noble cities, surrounded with stone cemented with fat earth; that the houses of these cities have no roofs, but are open above, like a platform, as you see them drawn on the map; that, besides the above-mentioned cities, there are above a hundred towns, great and small, round that sort of sea, upon which they navigate with such boats as you see drawn on the map," etc.

Now, this description does not, in any particular, correspond with the Great Salt Lake; and if it was told by the savages to the baron might, with as much if not far greater propriety, be considered as referring to the Pacific Ocean, with the Columbia flowing into it.

The story of La Hontan excited much speculation and received various additions in his day; and the lake finally became represented on the published English maps of as late date as 1826 (see Plate III) as being the source of two great navigable rivers flowing into the South Sea. Here it was that historians supposed the Aztecs were located before their migration to Mexico.

Father Escalante, in 1776, traveled from near Santa Fé, New Mexico, in a northwesterly direction, to the Great Colorado. After crossing it and passing to the southwest through the country near its western bank, he turned again to the southeast, recrossed the stream, and proceeded to the Gila. During his journey he probably was in the vicinity of Utah Lake. He there met with Indians who told him of a lake to the north whose waters produced a burning sensation when they touched the skin. This lake was perhaps the Great Salt Lake; and its property of making a burning sensation when applied to the skin was probably the effect of the strong solution of salt which it contains. This lake was *not* visited by Father Escalante; and that which he represents on his map, and which is copied on Humboldt's New Spain as Lake Timpanogos, was probably what is now called Lake Utah, into which a stream flows called by the Indians Timpanogos River.

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A portion of the Great Basin system was visited by Father Font as early as 1777, near the Mojave River (which he called Rio de los Mortires). He followed its course to the place where it sinks, and then traveled east, crossing the Colorado at the Mojave valleys, and kept on as far as the Moquis villages. A copy of his map was procured in California by Captain Ord, U. S. A., and is now on file in the Topographical Bureau.

IRVING'S ASTORIA.

"*Astoria, or Anecdotes of an Enterprise beyond the Rocky Mountains. By Washington Irving. Author's revised edition, complete in one volume. New York: G. P. Putnam*—1849." It contains a reduced copy of Wilkes's map of Oregon, and is the only edition at my command.

This beautifully written book, published first, I believe, in 1836, contains an account of the voyages and journey performed by Mr. Astor's parties. One of these, under Messrs. Hunt and Crook, went, in 1811 and 1812, from the Arikaree village, on the Missouri, at the mouth of Grand or "Big River," westward through the Black Hills and Big Horn Mountains to Wind River, and thence to the sources of the Snake or Lewis River, and down that stream to the Columbia.

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MAP OF LIEUT. E. STEEN, U. S. DRAGOONS, 1836.

This map exhibits the country from the west boundary of Arkansas and Missouri to the Rocky Mountains, between the 31st and 45th parallels, on a scale of 20 miles to an inch. It shows the route of the rangers under Colonel Manny, in 1833, who made an excursion from Fort Gibson westward as far as the head of the Little River, and back, and of the routes of the dragoons under Colonel Dodge, in 1834 and 1835.

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Capt. R. B. Marcy, U. S. A., has since explored all this section, and information concerning it can be found in his reports.

The expedition under Colonel Dodge in 1835 started from Fort Leavenworth, proceeded up the Platte and South Fork to its source, then traveled south to the Arkansas, and returned by it and the Santa Fé road to Fort Leavenworth.

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TOPOGRAPHICAL BUREAU MAP OF THE WESTERN FRONTIER, 1837.

This is "*A map illustrating the plan of the defenses of the western and north western frontier, as proposed by Charles Gratiot, in his report of October* 31, 1837, *compiled in the United States Topographical Bureau, under the direction of Col J. J. Abert, United States Topographical Engineers, by W. Hood.*"

This map was published (Senate document No 65, second session Twenty-fifth Congress) on a scale of 50 miles to an inch. It embraces the territory of the United States from the Gulf of Mexico to the 45th parallel of north latitude, and from the Mississippi River west to near the 103d meridian.

New Orleans and St. Louis are both represented as being in longitude 90° 25′.

SURVEY OF C. DIMMOCK IN 1838.

This survey, made with chain and compass for a military road along the western borders of Arkansas and Missouri, between Fort Smith and Fort Leavenworth, is still valuable between Old Fort Scott and Fort Smith, as it has not here been replaced by the United States Land Office surveys.

TOPOGRAPHICAL BUREAU MAP OF OREGON, 1838.

The title of this is "*A map of the United States territory of Oregon west of the Rocky Mountains, exhibiting the various trading depots or forts occupied by the British Hudson Bay Company connected with the western and northwestern fur trade, compiled in the Bureau of Topographical Engineers, from the latest authorities, under the direction of Col. J. J. Abert, by Washington Hood,* 1838. *M. H. Stansbury, del.*"

This map accompanies the report of Mr. Linn, from "the select committee to which was referred a bill to authorize the President of the United

States to occupy the Oregon Territory, submitted to the Senate," which report forms Senate document 470, second session Twenty-fifth Congress.

The map is published on a scale of 25 miles to an inch, and embraces the territory of North America from the 38th to the 55th parallel west of the 102d meridian.

All of this map, between the 40th and 50th parallels, with some trifling changes, was published in Wyndham Robertson's work, entitled "Oregon, our Right and Title," etc., published in Washington, 1846.

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MEMOIR AND MAP BY CAPTAIN HOOD, 1839.

Capt. Washington Hood, Topographical Engineers, while stationed on the Missouri frontier, compiled in 1839 a map, on a scale of 42 miles to an inch, of the country adjacent to the headwaters of the Missouri, the Yellowstone, the Salmon, the Lewis, and the Colorado, with various observations on the subject of the practicable passes or routes through the Rocky Mountains to the Pacific, "from information obtained in frequent conversations with two highly intelligent trappers, William A. Walker, of Virginia, and Mr. Coates, of Missouri, who belonged originally to Captain Bonneville's party, but subsequently continued to roam the mountains as free trappers during six consecutive years; as also that derived from others, who were connected with surveys and expeditions as far to the westward as Santa Fé and Taos."

This map is correct in its main features, but neither it nor the notes were ever published.

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SURVEY OF THE BOUNDARY BETWEEN LOUISIANA AND TEXAS IN 1840.

The journal of the commission will be found in Senate document No. 199, second session, Twenty-seventh Congress, and is accompanied by two maps. One, on a scale of 1½ miles to an inch, gives the Sabine River; and the other, on a scale of 4 miles to an inch, represents the meridian boundary line between the Sabine and Red Rivers, the initial point being the place where the Sabine is crossed by the parallel of 32° north latitude.

The surveys on the part of the United States of the portion north of the Sabine River were made by Lieut. Col. James Kearney, Lieut. J. Edm.

Blake, and Lieut. L. Sitgreaves, Topographical Engineers; and along the Sabine River by Maj. J. D. Graham, Lieut. T. J. Lee, and Lieut. G. G. Meade, Topographical Engineers. The surveys on the part of Texas were by Messrs. P. J. Pellows, D. C. Webber, and A. B. Gray.

UNITED STATES EXPLORING EXPEDITION UNDER COMMANDER CHARLES WILKES, U.S.N.

"*Narrative of the United States Exploring Expedition during the years* 1838, 1839, 1840, 1841, *and* 1842, *by Charles Wilkes, U. S. N., commander of the expedition, member of the American Philosophical Society, etc., in five volumes, and an atlas. Philadelphia: Lea & Blanchard.*—1845." The map extends from the 40th to the 53d parallel, and from the 106th meridian to the Pacific, on a scale of about 48 miles to an inch.

This naval exploring expedition arrived in Oregon in 1841.

A party under Lieutenant Johnson started from Nisqually, crossed the Cascades near Mount Rainier, and reached the Columbia near the mouth of the Pisquose River. Crossing the Columbia they proceeded to Fort Okinikaine, thence to the mouth of the Spokane, and thence north to Fort Colville. They then turned south, visited the Mission, and continuing on struck the Kooskoosky, about forty miles below where Lewis and Clark struck it; thence they traveled to Fort Walla-Walla. From this point they returned to Nisqually by the valley of the Yakima River, crossing the Cascade Mountains at its source.

The Columbia River was surveyed as far up as Walla-Walla, and a party was dispatched up the valley of the Willamette, and thence to the sources of the Sacramento, down which they traveled to the bay of San Francisco.

KENDALL'S NARRATIVE—SANTA FÉ EXPEDITION, 1841.

"*Narrative of the Texan Santa Fé Expedition, comprising a description of a tour through Texas, and across the great southwestern prairies, the Comanche and Caygua hunting grounds, with an account of the sufferings from want of food, losses from hostile Indians, and final capture of the Texans, and their march as prisoners to the city of Mexico, with illustrations and a map. By George Wilkins Kendall; in two volumes. New York: Harper & Brother,* 82 *Cliff street.*—1844." The map is on a scale of 45 miles to an inch, bounded on the north by the 38th parallel, on the east by the 91st meridian, on the south by the 19th parallel, and on the west by the 103d meridian.

This expedition left Austin, the capital of Texas, on the 21st of June, 1841. Mr. Kendall, the author of the narrative, accompanied the expedition from motives of mere curiosity and a desire of travel, being fully impressed with the idea that it was entirely a commercial expedition, and not one that would render null his passport received from the Mexican consul at New Orleans. The entire military force consisted of six companies, averaging forty men each. There was a large train of wagons containing the property of merchants who accompanied the expedition to trade at Santa Fé. The whole party was under the command of General McLeod. * * * This expedition, it is thought, may have been the first to visit the sources of Red River, but it furnished no topographical information which could be accurately represented upon a map.

I. N. NICOLLET'S EXPLORATIONS, 1836 TO 1840.

This report and map was printed by the Senate, document No 237, Twenty-sixth Congress, second session; the title being "*Report intended to illustrate a map of the Hydrographical Basin of the Upper Mississippi River, made by I. N. Nicollet while in employ under the Bureau of the Corps of Topographical Engineers. February* 16, 1841.—*Ordered to be printed, and* 200 *additional copies for the use of the Senate. Washington: Blair & Rives, printers.*—1843." The map accompanying this document is on a scale of 1 to 1,200,000. "Reduced and compiled, under the direction of Col. J. J. Abert, in the Bureau of Topographical Engineers, by Lieut. W. H. Emory, from the map published in 1842, and from other authorities in 1843."

The map published in 1842 was on a scale of 1 to 600,000, and bore the title of "Map of the Hydrographical Basin of the Upper Mississippi River, from astronomical and barometrical observations, surveys, and information, by I. N. Nicollet, made in the years 1836, 1837, 1838, 1839, and 1840; assisted in 1838, 1839, and 1840, by Lieut. J. C. Fremont, of the Corps of Topographical Engineers, and authorized by the War Department." Both of these maps comprised the valley of the Mississippi and country adjacent, from the parallel of 38° to 48° 30′ north, between the

89th and 101st meridians west from Greenwich, and contained, in addition to the results of Mr. Nicollet's own observations and determinations, a compilation of nearly all previous authentic explorations within these limits.

Mr. Nicollet says in his introduction that "having come to this country for the purpose of making a scientific tour, and with a view of contributing to the progressive increase of knowledge in the physical geography of North America, I determined, after having explored the Alleghany range in its various extension through the Southern States, and having ascended the Red River, Arkansas River, and to a long distance the Missouri River, to undertake the full exploration of the Mississippi River from its mouth to its very sources. During the five years that I was engaged in these excursions I took occasion to make numerous observations calculated to lay the foundation of the astronomical and physical geography of a large extent of country, and more especially of the great and interesting region between the Falls of St. Anthony and the sources of the Mississippi. With these labors I connected, also, the study of the customs, habits, manners, and languages of the several Indian nations that occupy this vast region of country. At the expiration of this long (and I found it an arduous) journey, I returned to Baltimore among my good friends of St. Mary's College, where I soon received a flattering invitation from the War Department and Topographical Bureau to repair to Washington. The result of my travels was made known to these departments, upon which they thought proper to intrust me with the command of an expedition to enable me to complete to the greatest advantage a scheme which I had already projected on my visit to the far west, namely, the construction of a geographical and topographical map of the country explored." This was in the spring of 1838.

The years 1838 and 1839 were spent in explorations in Minnesota, assisted by Lieutenant Fremont. Mr. Nicollet had nearly completed the map, and written a portion of his report, when death put an end to his labors before he was enabled to finish it, or to revise what had been previously written. The report does not, therefore, do justice to the surveys, and it is impossible to specify the routes he pursued except for the years of 1836, 1838, and 1839, and somewhat imperfectly for these, even though I have consulted his original notes in the Topographical Bureau. The reconnaissances of these years are the ones which, topographically, have at present the greatest value, as nearly all the others made by him have since been replaced by more accurate surveys under the General Land Office. Wherever Mr. Nicollet went he was indefatigable in the use of the telescope for observing occultations and eclipses, and of the sextant, with which he was very skillful; with these, a pocket chronometer, artificial horizon of mercury, and barometer, he obtained results possessing remarkable accuracy for the means employed.

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Mr. Nicollet was the first explorer who made much use of the barometer for obtaining the elevation of our great interior country above the sea. An abstract of the methods and principles by which he was governed in his explorations is given in his report, and have served as a guide to many subsequent explorers. His map was one of the greatest contributions ever made to American geography.

EXPLORATION OF LIEUT. J. C. FREMONT, TOPOGRAPHICAL ENGINEERS IN 1842.

The report of this expedition is S. Doc. No. 243, Twenty-seventh Congress, third session, and is entitled "*An Exploration of the Country lying between the Missouri River and the Rocky Mountains, on the line of the Kansas and Great Platte Rivers.*" It is illustrated by a map on a scale of 1 to 1,000,000 (nearly 16 miles to an inch), embracing the country from the forks of the Platte to the South Pass, between the forty-third and forty-fifth parallels.

Lieutenant Fremont's party consisted of about twenty-five persons, all mounted except eight who drove the carts carrying their stores. He was assisted by the since well-known topographer, Mr. Charles Preuss, and provided with chronometers, sextant, artificial horizon, telescope for observing occultations, and a barometer.

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Lieutenant Fremont made, throughout this journey, astronomical observations whenever circumstances permitted. His barometer was broken among the Wind River Mountains.

EXPLORATION BY CAPT. N. BOONE, UNITED STATES DRAGOONS, 1843.

The manuscript copy of this map, report, and journal I obtained from the files of the Adjutant-General's Office, and it is exceedingly interesting as containing an account of a country almost unknown. The map is on a scale of 20 miles to an inch. It exhibits the country between the Arkansas and Canadian Rivers as far west as the 100th meridian. It contains no meridians or parallels, as no astronomical observations were made. Captain Boone says: "It is a map or rough sketch of the country, with the water courses running through it. The courses and distances are all estimated from point to point direct, and not according to the distance actually traveled during each day, as it was found impossible to note the courses and distances of the windings made during each day's march." This report is accompanied by a minute journal, covering fifty-five pages of letter paper, closely written, and is referred to by General Taylor, in transmitting it, as containing "much valuable and curious information, particularly in relation to the salt region on the Red Fork of the Arkansas." The map and report have never been printed.[*]

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EXPEDITION OF CAPT. J. ALLEN TO SOURCE OF DES MOINES RIVER, ETC., 1844.

The report and journal of this expedition form printed House Doc. No. 168, 1st session 29th Congress. No map was printed with this report. Captain Allen submitted a map of his route with it, concerning which he makes the following remarks: "For the actual route passed over I must refer to the accompanying map, which will show it more fully and completely than it could be made by any other description. The map was constructed by Lieutenant Potter, under my immediate direction, and the care of taking minute notes on the way and the pains taken during its projection by that officer to secure all the information within its reach, will warrant me in saying that it gives a very correct delineation of the country passed over, as also the topography of other parts of this territory, perhaps the most accurate on record." The Adjutant-General (R. Jones), in his letter transmitting this report to Secretary Marcy, says: "Instead of the map of the route accompanying the report, I submit the more perfect map of the Upper Mississippi by Nicollet (from which Captain Allen's sketch no doubt was taken), upon which the route of the troops under his command has been carefully traced in the Topographical Bureau. Should it be determined to publish Captain Allen's route, Colonel Abert is of opinion it would be best to use the plate prepared for Nicollet's map. This would be not only much less expensive, but would probably improve the original map, which is one of much value."

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[*] Though I am not aware that this map was ever published by the Government, the principal topographical information which it contained was embraced in a map published by the Messrs. Harper, in 1847, entitled "Harper's Cereographic Map of the United States. By Samuel Breese, A. M."

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The expedition under Captain Allen consisted of J. S. Griffin, assistant surveyor; First Lieut. P. Calhoun, 2d dragoons; Second Lieut. P. Noble, 1st dragoons; Second Lieutenant Potter, 1st infantry, and 52 soldiers. Captain Allen was supplied "with a small imperfect sextant," and no chronometer.

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A portion of this route along the Big Sioux has not been reconnoitered since.

TOPOGRAPHICAL BUREAU MAP OF TEXAS, 1844.

The title of this is "*Map of Texas and the countries adjacent, compiled in the Bureau of the Corps of Topographical Engineers, from the best authorities, for the State Department, under the direction of Col. J. J. Abert, chief of the corps, by W. H. Emory, 1st lieutenant Topographical Engineers, War Department*, 1844," on a scale of about 70 miles to an inch.

This gave most of the information extant, at the date of compilation, respecting the country comprised between the Gulf of Mexico and the Mississippi River on the east to the Pacific Ocean on the west, between the twenty-second and forty-second parallels of north latitude. No mountains are indicated, except those inclosing the Rio Grande Valley. A lake, in the approximate position of the Great Salt Lake, is represented, and another one receiving the waters of Ogden's or Mary's River. There are no names on the lakes and rivers represented in these interior basins; but this compilation shows that the existence of these basins and lakes was, at that time, admitted as an established fact in the Topographical Bureau.

GREGG'S COMMERCE OF THE PRAIRIES, 1844.

The title page of this book is "*Commerce of the Prairies, or the Journal of a Santa Fé Trader, during eight expeditions across the Great Western Prairies, and a residence of nearly nine years in Northern Mexico, illustrated with maps and engravings. By Josiah Gregg, in two volumes. New York: Henry G. Langley,* 8 *Astor House.*—1844."

The map which accompanies the book is on a scale of 57 miles to an inch, and embraces the country from the west boundary of Missouri, Arkansas, and Louisiana, to the 108th meridian. It is based on the map of Humboldt's New Spain, that of Major Long's first expedition, and that of the road survey of J. C. Brown along the Santa Fé trail, with such corrections and additions as Mr. Gregg's own observations suggested. It was one of the most useful maps of this region at that day. The book is an interesting and valuable description of all the then known portions of New Mexico, and of the country along the routes between Fort Leavenworth and Santa Fé, and between Santa Fé and Fort Smith.

CHAPTER III.

EXPLORATIONS FROM A. D. 1843 TO A. D. 1852.

Capt. J. C. Fremont, T. E., exploration, 1843–'44.—Capt. J. C. Fremont, exploration in 1845–'46.—Lieut. J. W. Abert, T. E., reconnaissance, 1845.—Lieut. W. B. Franklin, T. E., reconnaissance, 1845.—Bvt. Maj. W. H. Emory, T. E., reconnaissance, 1846–'47.—Lieut. J. W. Abert, T. E., reconnaissance, 1846–'47.—Lieut. Col. P. St. George Cooke, U. S. A., expedition, 1846–'47.—A. Wislizenus, M. D., examination, 1846–'47.—Bvt. Capt. W. H. Warner, T. E., reconnaissance, 1847 to 1849.—Lieut. G. H. Derby, T. E., reconnaissance, 1849.—Lieut. J. D. Webster, T. E., survey mouth of Rio Grande, 1847.—Lieut. J. H. Simpson, T. E., reconnaissance along the Canadian River, 1849.—Lieut. J. H. Simpson, T. E., reconnaissance Navajo country, 1849.—Capt. R. B. Marcy, U. S. A., expedition, 1849.—Capt. H. Stansbury, T. E., expedition to Great Salt Lake, 1849–'50.—March of Rifle Regiment to Oregon, 1849.—Major Wood, U. S. Infantry, and Captain Pope T. E., expedition to Red River, 1849.—Brevet Lieutenant-Colonel Johnson, T. E., reconnaissances in Texas, 1849 to 1851.—Togographical Bureau map of territory of the United States west of the Mississippi, 1850.—R. H. Kern, C. E., reconnaissance on the Pecos River, 1850.—Lieut. J. G. Parke, T. E., Map of New Mexico, 1851.—Captain Sitgreaves, T. E., and Lieutenant Woodruff, T. E., boundary of Creek country, 1850–'51.—Captain Sitgreaves, T. E., expedition to Zuñi and Colorado Rivers, 1851.—Lieut. G. H. Derby, T. E., reconnaissance mouth of Colorado River, 1851.—Lieut. I. C. Woodruff, T. E., reconnaissance, 1852.—Capt. R. B. Marcy, U. S. A., expedition to sources of Red River.

CAPT. J. C. FREMONT'S SECOND EXPLORATION, 1843 AND 1844.

The title of the printed report is, "*Report of the Exploring Expedition to the Rocky Mountains in the year* 1842, *and to Oregon and North California in the years* 1843–'44. *By Brevet Captain J. C. Fremont, of the Topographical Engineers, under the orders of Colonel J. J. Abert, chief of the Topographical Bureau; printed by order of the Senate of the United States. Washington: Gales & Seaton, printers.*—1845." Senate Doc. No. 174, Twenty-eighth Congress, second session.

This book contains a reprint of the report of the exploration in 1842, and the accompanying map exhibits the routes followed during that expedition, as well as during the years 1843 and 1844. The longitudes given on this map and in this report (pp. 100 and 101) differ materially from those of the first report and map; the reason for the change being explained on page

321. The new map is on a scale of 32 miles to an inch, and is "strictly confined to what was seen and to what was necessary to show the face and character of the country." It was drawn by Charles Preuss, whose skill in sketching topography in the field and in representing it on the map has probably never been surpassed in this country. The map, which in most respects may serve for a model, exhibits also a profile, made from barometrical observations, drawn with a horizontal scale of 1 to 3,000,000, or 47.35 miles to an inch, and a vertical scale about thirty times greater, or 8,500 feet to the inch.

A "topographical map of the road from Missouri to Oregon, commencing at the mouth of the Kansas, in the Missouri River, and ending at the mouth of the Walla-Walla, in the Columbia, in seven sections, from the field notes and journal of Capt. J. C. Fremont,[*] and from sketches and notes made on the ground by his assistant, Charles Preuss, compiled by Charles Preuss in 1846, by order of the Senate of the United States," forms a part of House Committee Report No. 145, second session Thirtieth Congress. Its scale is 10 miles to the inch. It contains detailed topography and full notes of the route pursued by Captain Fremont (between the points named) in 1843, and is an excellent map for travelers. It is not, however, accurately constructed, according to the list of geographical positions given in Captain Fremont's report, and this should be borne in mind by compilers.

Throughout this lengthened exploration in the mountains and across the plains Lieutenant Fremont made many astronomical observations, determining longitude by observing occultations and eclipses with a telescope and by chronometric differences, and latitudes by observing with sextants and artificial horizons. After the investigations necessary in compiling the map which accompanies this memoir, I may be permitted to add my testimony to the truth of Captain Fremont's assertion in his notice to the reader at the beginning of his report, "that the correctness of the longitudes and latitudes may well be relied upon." They contain only such errors of longitude as are inherent to results obtained from observations made with the instruments employed. A mercurial barometer was carried across the continent on the road to Oregon as far as the Blue Mountains, where it was broken. The subsequent elevations on the route were determined by the temperature of boiling water.

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[*] Fremont did not receive his promotion to the rank of brevet captain until the termination of his second expedition.

The second expedition under Lieutenant Fremont left the town of Kansas on the 29th of May, 1843. The party consisted of twenty-nine men, all mounted, their stores, etc., being carried in twelve carts. He was assisted by Mr. Charles Preuss as topographer, Mr. Thomas Fitzpatrick as guide, and Mr. Theodore Talbot.

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EXPLORATIONS OF CAPT. J. C. FREMONT, 1845-'46.

A portion of the results of this was published by the United States Senate, first session Thirtieth Congress, Mis. Doc. No. 148, entitled: "*Geographical Memoir upon Upper California, in illustration of his Map of Oregon and California, by John C. Fremont, addressed to the Senate of the United States. Washington: Wendell & Van Benthuysen, printers.*" This is accompanied by a map, drawn by Charles Preuss, on a scale of 1 to 3,000,000, embracing all the country between the 104th meridian and the Pacific Ocean, and between the 32d and 50th parallels of north latitude. It was compiled from the surveys of Captain Fremont and "other authorities," and was at the time of its publication (1848) the most accurate map of that region extant.

A great deal of information in regard to this expedition, not contained in the memoir, has been published in the newspapers and in various pamphlets.

There are probably many reasons why a complete account of this third expedition, as well as Colonel Fremont's subsequent ones, has never been published; but this desideratum will probably be soon supplied.*

Captain Fremont started upon this exploration better provided than on his previous ones. He had under his command Lieuts. J. W. Abert and William G. Peck, Topographical Engineers, and was aided by Mr. Charles Preuss and Mr. E. M. Kern, as topographers and artists. He was provided with a portable astronomical transit instrument, sextants, chronometers, and barometers. No map or account has been published of his route east of Bent's Fort, but I believe it is nearly that by which he returned in 1844 He left the frontier of Missouri in May, and on arriving at Bent's Fort detached Lieutenants Abert and Peck to explore the sources of the Canadian River, and then to return to the States.

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*In press, Col. J. C. Fremont's Explorations, prepared by the author, and embracing all his expeditions. Childs & Peterson, publishers, No. 602, Arch street, Philadelphia.

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It is probable that the war with Mexico and the troubles between Americans and Mexicans in California, which began prior thereto, put a stop to his explorations beyond what could be obtained by ordinary observations in traveling from point to point during a period of violent hostilities.

During this expedition Captain Fremont obtained the longitude of the mouth of Fontaine qui Bouit; of the camp at Great Salt Lake; of Lassen's farm, on Deer Creek; and of the Three Buttes, in Sacramento Valley. The first two results have never been tested by any other observer with a good instrument, but are generally received as correct. The other two have been tested by land-office surveys, and by Lieutenant Williamson's second Pacific railroad survey, connecting with the Coast Survey longitude of San Francisco. Both tests indicate that his results were close approximations to accuracy. These four determinations of Captain Fremont detected some errors in his previous map, amounting in one instance to 15′ in longitude, and which furnished the means for correcting them.

A note on Captain Fremont's map of routes of 1843–'44 gives the following descriptive information: "The Great Basin: Diameter 11° of latitude, 10° of longitude; elevation above the sea between 4,000 and 5,000 feet; surrounded by lofty mountains; contents almost unknown, but believed to be filled with rivers and lakes which have no communication with the sea, deserts and oases which have never been explored, and savage tribes which no traveler has seen or described." This note, with the map and accompanying report, have conveyed the idea that this basin is encircled by a ridge of mountains forming a *rim*. This was so represented on the map compiled by Mr. Preuss in 1848, and gave rise to the belief in the existence of two long ridges running east and west, lying on the north and south of the basin, which, however, by that time had been much reduced in extent

MARCH OF AN ARMY DIVISION FROM SAN ANTONIO DE BEXAR, TEXAS, TO SALTILLO, MEXICO, 1846.

An account of this march, from a topographical stand-point (accompanied by astronomical determinations of latitude and longitude), by Capt. George W. Hughes, Corps of Topographical Engineers, forms Senate Mis. Doc. No. 32, Thirty-first Congress, first session.

The division was under the command of Brig. Gen. John E. Wool. The topographical party preceded the troops, leaving San Antonio on September 23, 1846, and consisted of the following persons, viz: George W. Hughes, captain, Topographical Engineers; L. Sitgreaves, first lieutenant, Topographical Engineers; W. B. Franklin, second lieutenant, Topographical Engineers; F. T. Bryan, brevet second lieutenant, Topographical Engineers; Dan Drake Henrie, interpreter; James Dunn, hunter and guide; two wagoners, four laborers, and two private servants.

The distance from San Antonio to the west bank of the Rio Grande over the route traversed was 164 miles; that from the Rio Grande to Santa Rosa, 209 miles; from Santa Rosa to Monclova, 72 miles; and from Monclova to Parras, 181 miles. From Monclova reconnaissances were made to Quatro Cienegas and to Saltillo and beyond in several directions via Monterey.

During a long halt at Monclova the topographical engineers were engaged in making surveys of the surrounding country and astronomical observations, reconnaissances for long distances from the camp in different directions, making computations, plotting field-notes, and reducing observations. Immediately prior to the above march, Lieutenant Franklin had made a reconnaissance of the country from La Vaca to San Antonio, Texas. The topographical party was provided with the necessary instruments for the determination of geographical positions by latitude and longitude. The computed latitudes of forty-one stations, determined by observations with the sextant on Polaris, are given, and also eight longitudes. The latter were determined (with the exception of that of one point by lunar distances) by observations on the eclipses of Jupiter and satellites. A general topographical map (scale 5 inches to 1 mile) embracing all the routes reconnoitered accompanies the above Executive document, which shows also the trace of a route from Matamoras on the Rio Grande northward to San Antonio.

RECONNAISSANCE BY LIEUT. JAMES W. ABERT, TOPOGRAPHICAL ENGINEERS, 1845.

This report forms Senate Doc. No. 438, Twenty-ninth Congress, first session, and is accompanied by a map on a scale of about 32 miles to an inch, embracing the country from the 94th meridian to the Rocky Mountains, and between the Platte River and the 35th parallel.

Lieut. J. W. Abert, assisted by Lieut. William G. Peck, Topographical Engineers, having been detached at Bent's Fort by Captain Fremont, in 1845, with instructions from him to explore the Purgatory Creek, the Canadian and False Washita Rivers, left that fort on the Arkansas on the 15th of August, 1845, with a party of thirty men, four wagons, and sixty-three horses and mules. They were supplied with a chronometer and sextant.

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RECONNAISSANCE BY LIEUT. W. B. FRANKLIN, TOPOGRAPHICAL ENGINEERS, 1845.

An abstract of Lieutenant Franklin's journal, and a reduced copy of his map, on a scale of 75 miles to an inch, were published in House Ex. Doc. No. 2, first session Twenty-ninth Congress. The title of the map is: "Map of the Route pursued by the late Expedition under the command of Col. S. W. Kearney, United States 1st Dragoons, by W. B. Franklin, Lieutenant Topographical Engineers, attached to the expedition. 1845."

The original map is on a scale of 32 miles to an inch. The new information which it contained was published with Lieutenant Abert's map of his exploration, made in 1845, wherein credit is given to Lieutenant Franklin for the material taken from his map.

The expedition was under command of Col. S. W. Kearney, United States 1st Dragoons.

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An account of the expedition is given in Lieut. Col. P. St. G. Cooke's late book of "Scenes and Adventures in the Army."

RECONNAISSANCE OF MAJOR WM. H. EMORY, TOPOGRAPHICAL ENGINEERS, 1846-'47.

The report forms a part of Senate Ex. Doc. No. 7, first session of Thirtieth Congress, and is entitled: "*Notes of a Military Reconnaissance from Fort Leavenworth, in Missouri, to San Diego, in California, including parts of the Arkansas, Del Norte, and Gila Rivers. By Wm. H. Emory, Brevet Major*

Topographical Engineers, made in 1846–'47, with the advanced guard of the 'Army of the West.' Washington: Wendell and Van Benthuysen, printers.— 1848."[*]

It is accompanied by a map, on a scale of about 24 miles to an inch, exhibiting only that portion of the country and the routes that came under the observation of the parties. The map contains also a barometrical profile of the route across the continent, on a horizontal scale of about 24 miles to an inch, and a vertical scale of about 8,200 feet to an inch, the vertical scale being about 15 times the horizontal. A report by Lieutenant Abert of the portions of the route between Fort Leavenworth and Bent's Fort is also appended. Major Emory (then a first lieutenant of Topographical Engineers) was assisted by Lieut. W. H. Warner, Topographical Engineers, Lieut. James W. Abert, Topographical Engineers, Lieut. Wm. G. Peck, Topographical Engineers, Mr. J. M. Stanley, and Mr. Norman Bestor. His instruments were two box chronometers, two 8½-inch sextants, and one syphon barometer, which was the first mercurial barometer ever carried overland to the Pacific unbroken.

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Lieutenants Abert and Peck did not accompany Lieutenant Emory beyond Santa Fé, instructions being given them to make certain explorations in the neighboring region.

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RECONNAISSANCE BY LIEUTENANTS ABERT AND PECK, 1846-'47.

The results of these explorations are given by Lieutenant Abert's report, which forms a part of House Ex. Doc. No. 41, first session Thirtieth Congress. It is accompanied by a map, on a scale of 10 miles to an inch, exhibiting the portion of New Mexico between latitude 33° 30′ and 37°, and from the meridian of 104° 30′ to 108°. This map was also reduced and republished on Lieutenant Emory's map already described.

Lieutenants Abert and Peck commenced, on the 8th of October, the examination intrusted to them by Lieutenant Emory, after having previously visited certain mines. It does not appear that they were provided with any instruments for making astronomical observations, and the latitudes and longitudes used were those determined by Lieutenant Emory.

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[*] It was also published by the House of Representatives, House Ex. Doc. No. 41, first session, Thirtieth Congress.

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ROUTE OF COL. P. ST. G. COOKE, 1846-'47.

This officer's report forms a part of House Executive Document No. 41, first session Thirtieth Congress, and is accompanied by a map of his route, on a scale of 12 miles to an inch; his route is also represented on Emory's map.

Colonel Cooke was sent by General Kearny from La Joya to Santa Fé, to take command of the "Mormon battalion," en route for California. Proceeding to that place, he assumed command, and on the 19th October, 1846, led the battalion, consisting of about four hundred men, each company having three mule wagons, down the Rio Grande to a point about three or four miles above San Diego, on that river.

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EXAMINATIONS BY A. WISLIZENUS, M. D., 1846-'47.

The account and results of this form Senate Mis. Doc. No. 26, first session Thirtieth Congress, and are entitled: "*Memoir of a tour to Northern Mexico, connected with Colonel Doniphan's Expedition, in* 1846 *and* 1847. *By A. Wislizenus, M. D., with a scientific appendix and three maps. Washington: Tippin & Streeper, printers.*—1848." These maps are, 1st, a map of the country from the 25th to the 39th parallel, between the 94th and 107th meridians, on a scale of 50 miles to an inch, exhibiting the topography of the route traveled over; 2d, a map or geological sketch of the same country, on a scale of 80 miles to an inch; and 3d, a barometrical profile of the route, on a horizontal scale of 36 miles to an inch and a vertical scale of 2,000 feet to the inch, the vertical scale being 95 times the horizontal.

Dr. Wislizenus undertook this scientific tour at his private expense. Leaving St. Louis in the spring of 1846, he followed the Santa Fé road, by the Cimarron route, to Santa Fé. Thence he went down the Rio Grande Valley to El Paso and Chihuahua. Here the derangement which the Mexican war produced kept him for six months "in a very passive condition." On Colonel Doniphan's arrival in that neighborhood he accepted a situation in the medical department of the Army, and returned with the troops, by way of Monterey, to the States.

EXPLORATION OF BVT. CAPT. W. H. WARNER, TOPOGRAPHICAL ENGINEERS, 1847 to 1849.

Very little of the results of the exploration of Brevet Captain Warner, after he was relieved from duty with Major Emory, have been published. He made extensive examination of routes along the Pacific and in the Coast Mountains, from San Diego to San Francisco, and had nearly completed his map of that then unknown section of country when he was directed to make the exploration in the Sierra Nevada, on which he lost his life in an Indian ambuscade. His notes and papers passed into the possession of his assistant, Lieutenant Williamson, Topographical Engineers, and were thus available to him in his examinations made in 1853–'54, in connection with a route for a railroad to the Pacific.

The only portion of Captain Warner's explorations, to my knowledge, of which a map and report were published, was that of his last expedition. This was prepared by Lieutenant Williamson, and forms a portion of Senate Ex. Doc. No. 47, first session Thirty-first Congress. The map of the route is on a scale of 15 miles to an inch. * * * In about latitude 42° Captain Warner was surprised on the march by an ambush of Pit River Indians, and he and several of his party were killed. This rendered the further prosecution of the reconnaissance impossible, and Lieutenant Williamson returned to Benicia. Captain Warner's note-books were saved, and from them a sketch of his route, with a report, was made by Lieutenant Williamson.

GEOLOGICAL EXPLORATIONS IN THE LAKE SUPERIOR REGION LAND DISTRICT, BY J. W. FOSTER AND J. D. WHITNEY, 1847 TO 1850.

These explorations to obtain a knowledge of the physical geography, climate, and geology of the copper and iron regions bordering on Lake Superior were made by Messrs. Foster and Whitney in or about the years 1848, 1849, and 1850. It would appear that the U. S. Land Office surveys were the basis upon which the work proper of this survey was compiled. Messrs. Foster and Whitney were in charge of the survey a little more than two years, and were aided by Messrs. James Hall, of New York, E. Desor, of Massachusetts, and Charles Whittlesey, of Ohio; also for a part of the time by Mr. S. W. Hill, of Michigan, and Mr. John Burt, for many years a surveyor in that region, who placed his notes at their disposal.

The report is addressed to Hon. Justin Butterfield, Commissioner of the Land Office. It is in two parts.

Part I, made in 1850 and published in 1851, gives a historical sketch of the explorations, a description of the physical geography and climate, and so much of the geology as was necessary to the full elucidation of the copper-bearing rocks and their relation to the sedimentary formations.

Part II forms Senate Ex. Doc. No. 4, special session, March, 1851, and has title, "The Iron Regions," together with the general geology; ordered to be printed March 13, 1851. Printed by A. Boyd Hamilton, Washington, 1851. In this a detailed and systematic description, as far as the materials would permit, is made of the geology of the whole of the Lake Superior region, commencing with the bed formations and ascending to those which are now in process of accumulation.

The report was accompanied with sections, illustrations, and a general map on which the range and extent of the general systems of rock are defined. The observations were extended over an area of little less than 100,000 square miles.

Chapter IX, on Magnetic Variations, Comparison of Terrestrial and Astronomical Monuments, by Charles Whittlesey, General Warren states, "will have a permanent geographical interest and value as long as the United States land surveys form the basis of our maps."

GEOLOGICAL EXAMINATION OF WISCONSIN, IOWA, AND MINNESOTA, AND PORTIONS OF NEBRASKA, BY DAVID DALE OWEN.

The published results of this investigation appear in the form of a "*Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, and incidentally of a portion of Nebraska Territory, made under instructions from the U. S. Treasury Department by David Dale Owen, U. S. Geologist. Philadelphia: Lippincott, Grambo & Co.—1852.*" (1 vol., 4°, pp 638.)

This work made large additions to geographical as well as geological information. The final report made to Hon. J. Butterfield, Commissioner of the Land Office, embraces in a connected and revised form the substance of all the preliminary reports made from time to time and of the annual reports for 1848, 1849, together with a full statement of the result of the last year's operations. It is accompanied by condensed reports of the assistant geologist and of the heads of sub-corps, which contain detailed distributions of the districts assigned to each, together with generalizations deduced therefrom. The names of the following gentlemen are acknowledged: J. G. Norwood, assistant geologist; J. Evans, B. F. Shumard, B. C. Macy, C. Whittlesey, A. Litton, and R. Owen, heads of sub-corps; G. Warren, H. Pratten, F. B. Meek, and J. Beal, sub-assistants.

Accompanying the report is a general map, 1 to 1,200,000, on which the different geological formations are represented by distinct colors. It includes latitude 38° to 49°, longitude 89° 30′ to 96° 30′.

The report contains many illustrations in scenery, sections, diagrams, plates of fossils, and detail maps. Among the latter may be enumerated a map of the north shore of Lake Superior; of the Mississippi from the mouth of the Wisconsin River to the Falls of St. Anthony; of the Wisconsin River from the mouth up to Whitney's Rapids; of the Missouri River from its mouth to the Big Sioux River, in two sheets; of the Des Moines River from its mouth up to Lizard Fork, in two sheets. These maps of rivers exhibit sections showing the geological formations of the bluffs. There is also a map of the Bad Lands, which is imperfect in its representation.

A party under Dr. Evans examined the Missouri River in 1849 as high up as Fort Berthold, the Fox Hills north of the Cheyenne River, and the Bad Lands on the White River.

A party under Dr. Shumard ascended the Minnesota River as far as the mouth of Red Wood River, a tiny stream. Dr. Owen ascended the Mississippi as high as Crow Wing; thence by that river and Otter Fort River he passed into the valley of the Red River of the North, and along it to Fort Garry in the British Provinces.

Many barometrical observations were made and altitudes deduced.

RECONNAISSANCE IN CALIFORNIA BY LIEUT. G. H. DERBY, TOPOGRAPHICAL ENGINEERS, 1849.

A report of certain of these examinations forms a part of Senate Ex. Doc. No 47, first session, Thirty-first Congress, and is accompanied by a map of the Sacramento Valley from the American River to Butte Creek, surveyed and drawn by order of General Riley, commanding Tenth Military Department, by Lieutenant Derby, Topographical Engineers, September and October, 1849, on a scale of 10 miles to an inch.

SURVEY OF THE MOUTH OF RIO GRANDE, BY LIEUT. J. D. WEBSTER, TOPOGRAPHICAL ENGINEERS, 1847.

The report of this forms Senate Ex. Doc. No. 65, first session Thirty-first Congress. The map is on a scale of an inch to a mile and exhibits the windings of the river from Matamoras to its mouth.

SURVEY OF A ROAD FROM FORT SMITH TO SANTA FÉ, BY LIEUT. J. H. SIMPSON, TOPOGRAPHICAL ENGINEERS, 1849.

The report of this survey forms Senate Ex. Doc. No. 12, first session Thirty-first Congress, and is accompanied by a map of the route, in four sheets, on a scale of one inch to 10 miles. The survey was made with chain and compass, checked by astronomical observations made with a sextant and chronometer.

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RECONNAISSANCE IN THE NAVAJO COUNTRY, BY LIEUT. J. H. SIMPSON, TOPOGRAPHICAL ENGINEERS, 1849.

Lieutenant Simpson's report of this expedition forms part of Senate Ex. Doc. No. 64, first session, Thirty-first Congress, and is accompanied by a map of the route pursued, on a scale of an inch to 10 miles.*

This expedition, the object of which was the chastisement of the Navajo Indians, was under the command of Bvt. Lieut. Col. J. M. Washington. Lieutenant Simpson was assisted in his duties by Messrs. E. M. Kern and R. H. Kern, and was provided with a sextant and chronometer for astronomical observations. The whole command left Santa Fé on the 16th August, 1849.

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* This report is also published as part of House Ex. Doc. No. 45, Thirty-first Congress, first session.

EXPEDITION OF CAPT. R. B. MARCY, FIFTH INFANTRY, 1849.

The report of Captain Marcy forms Senate Ex. Doc. No. 12, first session Thirty-first Congress,* and is accompanied by a map drawn on a scale of an inch to 36 miles, embracing the country from the Arkansas River south to the 31st parallel, between the 94th and 108th meridians. Captain Marcy went from Fort Smith to Santa Fé over the route surveyed by Lieutenant Simpson, Topographical Engineers. Of the remainder of his journey he prepared a map from notes taken by his command. He was not supplied with instruments for astronomical observations; his distances were measured with an odometer.

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EXPEDITION TO GREAT SALT LAKE, BY CAPT. H. STANSBURY, TOPOGRAPHICAL ENGINEERS, 1849-'50.

The report of this expedition forms Senate Ex. Doc. No. 3, special session, March, 1851, and is entitled: "*Exploration and Survey of the Valley of the Great Salt Lake of Utah, including a reconnaissance of a New Route through the Rocky Mountains. By Howard Stansbury, Captain Corps of Topographical Engineers, United States Army. Philadelphia: Lippincott, Grambo & Co.*—1852." It is accompanied by a map of the routes from the Missouri River to the Great Salt Lake, on a scale of 1 to 1,000,000 (about an inch to 16 miles), and by another of the Great Salt Lake and vicinity, on a scale of 1 to 240,000 (about 4 miles to an inch).

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MARCH OF RIFLE REGIMENT TO OREGON, 1849.

An account of this march by Maj. Osborne Cross, A. Q. M., forms an appendix to the Quartermaster-General's report to the Secretary of War. It is printed in House Ex. Doc No. 1, second session Thirty-first Congress.

This regiment, under Colonel Loring, marched from Fort Leavenworth to the Columbia River, with wagons.

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EXPEDITION TO THE RED RIVER OF THE NORTH, 1849.

The report of the commander of this expedition, Bvt. Maj. S. Woods, Sixth Infantry, U. S. Army, forms House Ex. Doc. No. 51, first session Thirty-first Congress. That of Capt. John Pope, Topographical Engineers, who was attached to the command, is to be found in Senate Ex. Doc. No. 42, first session Thirty-first Congress, and is accompanied by a map of the route, on a scale of an inch to 20 miles, based on the map of the Hydrographical Basin of the Upper Mississippi, by Mr. Nicollet, most of which latter map is here repeated. On the outward journey, Captain Pope measured the road with an odometer, took courses with a compass, and made observations for latitude with a sextant.

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* This report appears also as part of House Ex. Doc. No. 45, Thirty-first Congress, first session.

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RECONNAISSANCES IN TEXAS, BY BVT. LIEUT. COL. J. E. JOHNSTON, LIEUTS. M. L. SMITH, WILLIAM F. SMITH, F. T. BRYAN, AND N. MICHLER, TOPOGRAPHICAL ENGINEERS, AND LIEUT. H. C. WHITING, ENGINEERS, IN THE YEARS 1849 TO 1851.

No reports have as yet been published giving the whole extent of the explorations made in Texas by the above-mentioned officers. The following notice of such data as have come to my knowledge will therefore be the more acceptable. The reports of explorations that have been published form part of the Senate Ex. Doc. No. 64, first session Thirty-first Congress. The report of Capt. S. G. French, A. Q. M., of the southern route from San Antonio to El Paso, forms also a part of this document, which is accompanied by a map of the routes described, on a scale of an inch to 20 miles.

Lieut. William F. Smith, in February, 1849, started to explore a road from San Antonio to El Paso.

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Lieut. F. T. Bryan left San Antonio June 14, 1849, for El Paso, and taking nearly the same route as Lieutenant Smith to the San Saba River, crossed it, and traveled north to the north branch of Brady's River, where he struck west along the head of the Rio Concho, and thence to the Pecos at the Horse-head Crossing. Fording the river he traveled up its right bank to Salinas Creek; thence he struck northwestward to Delaware Creek, ascended it to its source, and crossed the Guadalupe Mountains, through the Guadalupe Pass; thence he proceeded to the Sierra de los Alamos, and thence through the Sierra Hueco to El Paso.

Colonel Johnston, in 1849, directed the construction of a road for the troops over the route discovered by Lieut. William F. Smith. * * *

On arriving at El Paso Colonel Johnston and Lieutenant Bryan surveyed the valley of the Rio Grande to Doña Ana, while Lieut. William F.

Smith examined the Organ Mountains north to Salina de San Andres, and the Sacramento Mountains between the Cañon del Perro and La Cienega.

Colonel Johnston and party returned to the Pecos by the route that Lieutenant Bryan had explored through the Gaudalupe Pass; thence they passed down the Pecos River to the mouth of Live Oak Creek, from which point they examined the direct route to Fort Inge, across the heads of the San Pedro and Nueces Rivers. During Colonel Johnston's reconnaissance the roads were measured with an odometer, and numerous observations were made with the sextant.

Lieut. N. Michler, in 1849, made a reconnaissance of the country from Corpus Christi to Fort Inge, along the valleys of the Nueces, Leona, and Frio Rivers, for the purpose of opening a military road.

Lieutenant Michler then examined the route from San Antonio to Fort Washita, passing through Austin, Navarro, Dallas, and Preston, and thence to the emigrant crossing of the Pecos. The return route from Fort Washita lay up the Red River to the mouth of the Little Washita, thence west to the Big Washita, thence southwest to the Double Mountain Fork, thence to the Big Springs of the Colorado, and thence through the White Sand Hills to the Pecos. From this point he returned to San Antonio over nearly the route previously explored by Lieutenant Bryan as far as the head of the Concho, where he struck southwest to the San Saba, and thence by Forts Mason and Martin Scott to San Antonio. The distances along the route from Fort Washita to the Pecos were chained. No mention is made of astronomical observations being taken on this journey.*

Capt. R. B. Marcy, Fifth Infantry, had just passed over the portion of the route from the Pecos to the Double Mountain Fork, and gave Lieutenant Michler information concerning it.

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An examination was also made of the Colorado, with the view of improving its navigation, by Lieut. William F. Smith, assisted by Messrs. R. A. Howard and J. F. Minter.

Lieutenant Whiting reconnoitered the route between San Antonio and Preston, via Fredericksburg, Fort Croghan, Fort Gates, Fort Graham, and

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* See House Ex. Doc. No. 67, Thirty-first Congress, first session.

Fort Worth. This route was also examined by Lieutenant Bryan, Topographical Engineers.

The above items are mainly from the printed reports or maps. The following information in regard to the unpublished maps of the explorations in Texas in 1850–'51 have been obtained from the officers engaged in the surveys. In the Topographical Bureau there are two maps, both incomplete, of these explorations; and each contains routes not upon the other.

In January, 1849, Lieutenants Bryan and Michler, Topographical Engineers, examined Aransas and Corpus Christi Bays, and the road from Corpus Christi to San Antonio, via San Patricio and Calaveras. In February, 1849, they made a reconnaissance of the lower road from San Antonio to the crossing near Presidio de Rio Grande, via Fort Inge; and also of a road from the San Fernando Crossing to San Antonio.

In May, 1849, Lieutenant Michler examined the road from San Antonio to Port Lavacca; and in June and July, 1849, the road between Corpus Christi and Fort Inge, along the Nueces, Frio, and Leona Rivers.

In May, 1850, Lieuts. William F. Smith and F. T. Bryan, Topographical Engineers, surveyed the Rio Grande with boats from El Paso to Presidio del Norte.

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From August to November, 1850, Lieut. M. L. Smith and N. Michler examined a road from San Antonio to Ringgold Barracks, via Fort Merrill, of which we have no map. They also surveyed the Rio Grande from Ringgold Barracks to a point 80 miles above the mouth of the Pecos.

In April, 1851, Lieutenant Bryan laid out and made a road from Austin to Fort Mason, of which we have no map.

In April, 1851, Colonel Johnston reconnoitered the western frontier of Texas from the headwaters of the Nueces to Fort Belknap, via the headwaters of the Llano, San Saba, Concho, and Clear Fork of Brazos.

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There were other surveys and reconnaissances made by these officers; but the maps are not available, and I have experienced more difficulty in compiling the map of Texas than that of any other portion. Throughout most of the above examinations astronomical observations were made for latitude. The longitude of San Antonio was determined by Colonel Johnston by moon culminations.

In April, 1851, Lieuts. W. F. Smith and N. Michler were placed on duty on the United States Mexican Boundary Survey. Lieutenant Bryan left Texas in the spring of 1852; Lieut. M. L. Smith in November, 1852; Colonel Johnston in the spring of 1853.

MAP OF THE TERRITORY OF THE UNITED STATES WEST OF THE MISSISSIPPI RIVER, ETC., [illegible]

To this map the following title was affixed: "*A map of the United States and their Territories, from the Mississippi River to the Pacific Ocean, and of part of Mexico; compiled in the Bureau of the Corps of Topographical Engineers, under a resolution of the United States Senate, from the best authorities which could be obtained.*"

This map was published on a scale of 50 miles to an inch, and contained material from the greater portion of the maps I have already described.

RECONNAISSANCE ON THE PECOS, BY MR. R. H. KERN, 1850.

A military reconnaissance of the Rio Pecos, as far south as the Bosque Grande, was made in 1850 by Mr. R. H. Kern, who was attached to the command of Capt. H. B. Judd, Third Artillery. It was probably made with a compass and estimated distances, and without any astronomical observations; but of this I have no positive information. The map of the reconnaissance was used by Lieutenant Parke in his compiled map of New Mexico in 1851.

MAP OF NEW MEXICO, COMPILED BY LIEUT. J. G. PARKE, TOPOGRAPHICAL ENGINEERS, IN 1851.

This map, by Lieutenant Parke, was a careful compilation of all the available and reliable information in relation to New Mexico which could be obtained at that date from trappers and hunters, as well as from actual survey. It was prepared by him, while in that country, by order of Bvt. Col. John Munroe, U. S. Army, commanding Ninth Military Department, and was drawn by R. H. Kern in 1851. It was subsequently reduced in the Bureau of Topographical Engineers, and published on a scale of 36 miles to an inch.

RECONNAISSANCE FROM SANTA FÉ TO FORT LEAVENWORTH, IN 1851, BY CAPT. J. POPE, TOPOGRAPHICAL ENGINEERS.

Captain Pope traveled on the Cimarron route as far as Cedar Creek, where he turned north and struck the Arkansas at the Big Timbers. Crossing this river he took a northeast course to the Smoky Hill Fork, and came upon it near where Captain Fremont struck it in 1844. From this point he traveled down the stream.

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SURVEY OF CREEK BOUNDARY, BY CAPTAIN SITGREAVES AND LIEUTENANT WOODRUFF, TOPOGRAPHICAL ENGINEERS, 1850-'51.

The report and map of this survey form printed House Ex. Doc. No. 104, first session Thirty-fifth Congress. The map is on a scale of 1 to 600,000, or about an inch to 9½ miles. Chain and compass were used in the survey, and the longitude of Fort Gibson was determined by moon culminations. A sextant was used to determine the latitudes.

The northern line begins on the parallel which passes near the mouth of the Red Fork of the Arkansas, at a point a little west of north from Fort Gibson, and continues west on the parallel to the 100th meridian.

RECONNAISSANCE DOWN THE ZUÑI AND COLORADO RIVERS, BY CAPT. L. SITGREAVES, UNITED STATES TOPOGRAPHICAL ENGINEERS, IN 1851.

The report of this forms Senate Ex. Doc. No. 59, second session of Thirty-second Congress, and is accompanied by a map of the routes pursued, on a scale of 10 miles to an inch. The reconnaissance was made with a compass and estimated distances, and checked by astronomical observation made with a sextant.

This expedition, under Captain Sitgreaves, assisted by Lieut. J. G. Parke, Topographical Engineers, Mr. R. H. Kern as topographer, and Dr. S. W. Woodhouse, surgeon and naturalist, was organized at Santa Fé, New Mexico, and consisted of about twenty persons, including packers and servants; pack-mules being used for transportation of provisions, etc. The party accompanied an expedition against the Navajos as far as Zuñi, which point they reached by the usual road from Albuquerque on the 1st of September, 1852.

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RECONNAISSANCE OF THE COLORADO RIVER, BY LIEUTENANT DERBY, TOPOGRAPHICAL ENGINEERS, [illegible].

The report of this forms Senate Ex. Doc. No. 81, first session Thirty-second Congress, and is accompanied by a map, on a scale 4 miles to an inch, of the Colorado River from its mouth to Fort Yuma. Lieutenant Derby was supplied with a sextant and chronometer.

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RECONNAISSANCE OF LIEUTENANT WOODRUFF, TOPOGRAPHICAL ENGINEERS, 1852.

Lieut. I. C. Woodruff, Topographical Engineers, made a reconnaissance, in 1852, of a portion of the Kansas River; of Walnut Creek; of Pawnee Fork; and of other streams lying between the Smoky Hill Fork of the Kansas and the Arkansas Rivers. These examinations were made for the purpose of selecting proper sites for military posts. The map and report prepared by Lieutenant Woodruff have never been published. The former was made from compass notes and estimated distances, checked by the astronomical determinations of Captain Fremont and Major Emory.

EXPEDITION TO THE SOURCES OF RED RIVER, BY CAPT. R. B. MARCY, UNITED STATES INFANTRY, 1852.

The report of this expedition forms Senate Ex. Doc. No. 54, second session Thirty-second Congress, House Ex. Doc., first session Thirty-third Congress, and is accompanied by numerous illustrations and by two maps, one of which exhibits the country from the 91st to the 114th meridian, lying between the 31st and 38th parallels, drawn on a scale of 24 miles to an inch; the other, on a scale of 10 miles to an inch, shows the country surrounding the sources of Red River.

Captain Marcy was assisted by Bvt. Capt. G. B. McClellan, Engineers, who made astronomical observations for latitude and longitude by means of a sextant and "pocket lever watch." The routes were mostly measured with an odometer, and observations were taken with a barometer. Dr. G. G. Shumard accompanied the expedition as surgeon and geologist.

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CHAPTER IV

EXPLORATIONS FROM A. D. 1852 TO A. D. 1857.

Gov. I. I. Stevens and Capt. G. B. McClellan, U. S. Engineers, exploring and surveying railroad route, 1853-'54-'55.—Lieut. R. Arnold, U. S. A., survey, 1854.—F. W. Lander, C. E., reconnaissance, 1854.—Capt. G. W. Gunnison, T. E., and Capt. E. G. Beckwith, U. S. A., exploring and surveying railroad route, 1853.—Capt. E. G. Beckwith, U. S. A., exploring and surveying railroad route, 1854.—Capt. A. W. Whipple, T. E., exploring and surveying railroad route, 1853-'54.—Lieut. R. S. Williamson, T. E., survey for railroad route, 1853-'54.—Lieut. J. G. Parke, T. E., exploring and surveying railroad route, 1854.—Capt. J. Pope, T. E., exploring and surveying railroad route, 1854.—Lieut. J. G. Parke, T. E., exploring and surveying railroad route, 1854-'55.—Lieut. R. S. Williamson, T. E., and Lieut. H. L. Abbott, T. E., exploring and surveying railroad route, 1855.—Maj. W. H. Emory, U. S. A., United States and Mexican boundary survey, 1849 to 1855.—Capt. J. L. Reno, U. S. A., survey, 1853.—Capt. R. B. Marcy, U. S. A., exploration, 1854.—Alexander Ross, fur hunters of the far West, 1855.—March of Colonel Steptoe's command to California, 1854-'55.—Lieut. J. Withers, U. S. A., survey of road, 1854.—Lieut. G. H. Derby, T. E., survey roads, 1854-'55.—Lieut. G. H. Mendel, T. E., reconnaissance, 1855.—Capt. J. H. Simpson, T. E., survey roads, 1855.—Lieut. G. K. Warren, T. E., reconnaissance, 1855.—Lieut. F. T. Bryan, T. E., reconnaissance, 1855.—Lieut. J. C. Amory, U. S. A., reconnaissance in 1855.—Major Merrill, U. S. A., reconnaissance, 1855.—Lieut. I. N. Moore, U. S. A., map part of New Mexico, 1855.—Lieut. E. L. Hartz, U. S. A., reconnaissance, 1856.—Lieut. F. T. Bryan, T. E., survey of road, 1856.—Capt. J. H. Dickerson, U. S. A., survey road, 1856.—Lieut. W. D. Smith, U. S. A., route, 1856.—Capt. A. Sully, U. S. A., reconnaissance, 1856.—Lieut. G. K. Warren, T. E., reconnaissance Missouri and Yellowstone, 1856.—Explorations ordered in 1857.

EXPLORATION AND SURVEY FOR A RAILROAD ROUTE NEAR THE FORTY-SEVENTH AND FORTY-NINTH PARALLELS, 1853 to 1855.

The report of this exploration and survey will be found in Vol. I,* Senate Ex. Doc. No. 78, second session Thirty-third Congress, and House Ex. Doc. No. 91, second session Thirty-third Congress. Quarto edition.

They are accompanied by a map, in three sheets, drawn on a scale of 1 to 1,200,000, exhibiting the entire exploration; and a sheet of profile on a horizontal scale of 1 to 3,000,000, the vertical scale being 1 to 60,000, or fifty times greater.

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*Vol. I also contains the report of the Secretary of War and Capt. A. A. Humphreys on the comparative advantages of the routes examined. These are accompanied by a map of the territory of the United States, from the Mississippi to the Pacific, on a scale of 1 to 3,000,000, and a sheet of profiles of all the routes on a horizontal scale of 1 to 3,000,000, and a vertical scale of 1 to 60,000.

A brief report of the progress of the survey was published in Senate Ex. Doc. No. 29, first session Thirty-third Congress, which is accompanied by a map of the route from St. Paul to Fort Union, drawn on a scale of 1 to 1,200,000.

A nearly complete report is contained in House Doc. No. 129, first session Thirty-third Congress, accompanied by a profile and map, in three sheets, showing the entire route, drawn on a scale of 1 to 1,200,000. This map is, however, not so complete as the one in the quarto edition.

An additional report has also been made by Governor Stevens, which will appear in a subsequent volume with numerous landscape illustrations.†

This expedition, as first organized, consisted of four separate parties. The one under Governor Stevens's personal supervision operated from St. Paul westward towards the mouth of White Earth River; thence on the prairies lying along the Missouri River to the Rocky Mountains, and then among the passes of that region. Another, under Bvt. Capt. G. B. McClellan, Engineers, began at Fort Vancouver, on the Columbia, operated northeastward, examining the passes of the Cascade Range, and then eastward to join Governor Stevens's party. Another party, under Lieut. A. J. Donelson, Engineers, examined the Missouri River from its mouth to the Yellowstone, where a junction was made with that under Governor Stevens. The fourth party, under Lieut. R. Saxton, United States artillery, conducted a reconnaissance from Fort Walla Walla to the Bitter Root Valley, where a depot was established.

The party under the immediate supervision of Governor Stevens took the field at St. Paul's on the 8th June. The principal engineer and scientific assistants consisted of Lieut. C. Grover, United States artillery; Dr. George Suckley, surgeon and naturalist; Messrs. F. W. Lander and A. W. Tinkham, civil engineers; Mr. J. Lambert, topographer; Mr. J. M. Stanley, artist; Mr. G. W. Stevens, assistant astronomer, and Mr. J. Moffett and Mr. J. Doty, meteorologists. Governor Stevens failed in securing the services of the officer designed to take charge of the astronomical observations.

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† Ordered by the Senate at the second session Thirty-fifth Congress.

The party was well supplied with suitable instruments. Odometers, compasses, barometers, thermometers, sextants, chronometers, and a portable astronomical transit of twenty-six inches focal length (which latter was not used).

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Lieutenant Saxton arrived at Fort Benton on the 12th of September. He had been charged with establishing a depot of supplies at St. Mary's village, and left The Dalles on the 18th of July, 1853. His party consisted of Lieuts. Robert Macfeely and Richard Arnold, Messrs. Arnold and Hoyt, and forty-nine enlisted men, packers, etc. They were provided with barometers, compasses, sextants, and chronometers. The distances were estimated.

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The party on the western division, under the command of Capt. George B. McClellan, consisted of Lieut. J. K. Duncan, Third Artillery, Lieut. S. Mowry, Lieut. H. C. Hodges, Mr. J F. Minter, civil engineer, George Gibbs, geologist, and Dr. J. G. Cooper, naturalist. Captain McClellan left Fort Vancouver in July, 1853.

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A large map of the Cascade Range, north of the Columbia, was prepared by Lieutenant Duncan on a scale of 1 to 400,000.

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Lieutenant Mullan, being left at Cantonment Stevens, on the Bitter Root River, to make observations in the mountains during the winter, made several reconnaissances. He was assisted by Mr. Adams as topographer and artist. The maps of the routes were made from compass courses and generally estimated distances.

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The reports of each of the reconnaissances made by the subordinates of Governor Stevens's expedition will be found with his printed report; and the various maps of these routes were compiled by Mr. Lambert on the map that accompanies it. Governor Stevens also made additional examinations in 1855, in connection with his official duties with the Indians, and the results will be published in a supplementary volume.

SURVEY BY LIEUT. R. ARNOLD, 1854.

In the summer of 1854 Lieut. R. Arnold, Third Artillery, made an odometer survey and map of a road which he opened from Puget Sound to Walla Walla, through the Nachess Pass, over nearly the same route reconnoitered by Lieutenant Hodges, of Captain McClellan's party, in 1853. His report will be found as an appendix to the annual report of Col. J. J. Abert, Topographical Engineers, forming part of Senate Ex. Doc. No. 1, first session Thirty-fourth Congress.

EXAMINATIONS BY MR. F. W. LANDER, CIVIL ENGINEER, 1854.

The report of Mr. Lander forms part of House Ex. Doc. No. 129, First Session Thirty-third Congress, and is reprinted in the quarto edition of Pacific Railroad Reports, Vol. II, Senate Ex. Doc. No. 78, and House Ex. Doc. No. 91, second session Thirty-third Congress. The report is unaccompanied by maps or sketches.

Mr. F. W. Lander returned to the States in 1854 by the emigrant road up the valley of the Columbia; thence across the Blue Mountains through the Grande Ronde; thence up Snake River and across to Bear River; and thence by the usual traveled road through the South Pass and down the Platte River to Missouri.

The journey was undertaken by him at the request of citizens of Oregon and Washington Territories, to endeavor to find a railroad route in this direction. Although he examined several approaches to the Blue Mountains from the west, he found no practicable railroad route, as time and means did not permit him to reconnoiter this portion as fully as he intended. It was also his design to examine a route from the source of Snake River over the mountains to the head of Green River, but an accident to himself prevented this. His examinations tended to confirm the opinion of the difficult nature of the route west of the South Pass.

EXPLORATION AND SURVEY FOR A RAILROAD ROUTE TO THE PACIFIC, NEAR THE THIRTY-EIGHTH AND THIRTY-NINTH PARALLELS, UNDER CAPT. J. W. GUNNISON, TOPOGRAPHICAL ENGINEERS.

The report of this examination was made by Capt. E. G. Beckwith, United States Artillery, and forms part of Vol. II of the quarto edition of the Pacific Railroad Report, Senate Ex. Doc. No. 78; House Ex. Doc. No.

91, second session Thirty-third Congress The maps were prepared by Mr. F. W. Egloffstein, and are in four sheets, on a scale of 12 miles to an inch.

The profile of this route is engraved on a horizontal scale of 30 miles to an inch, and a vertical scale $39\frac{1}{10}$ times greater than the horizontal. Numerous illustrations accompany the quarto edition. This report was also published in House Doc. No. 129, first session, Thirty-third Congress, and was accompanied by a preliminary map, on a scale of 50 miles to an inch, and profile on a horizontal scale of 15 miles to an inch, the vertical scale being 2,000 feet to an inch. A sketch of the portion of the route between the 104th and 110th meridian, on a scale of about 16 miles to an inch, accompanies the report of the Secretary of War—Senate Ex. Doc. No. 29, first session, Twenty-ninth Congress.

This expedition was composed of Captain Gunnison, Lieut. E. G. Beckwith, Third Artillery; Mr. R. H. Kern, topographer; Mr. S. Homans, astronomer; Dr. J. Schiel, surgeon and geologist; Mr. F. Creutzfeldt, botanist; and Mr. J. A. Snyder, assistant topographer; with the necessary teamsters and employés. They were escorted by Capt. R. M. Morris and Lieut. L. S. Baker, and about thirty soldiers of the regiment of mounted rifles. They were provided with sextants and artificial horizons, compasses, odometers, mercurial and aneroid barometers, and instruments for railroad surveying. Their supplies, etc., were transported in wagons.

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Messrs. Beale and Heap passed over nearly this same route in advance of Captain Gunnison's party on their way to California. The journey of these enterprising travelers was a very trying one; and they lost nearly everything they had in attempting to cross Grand River on a raft during a high stage of water. They published a brief and interesting narrative of their journey, accompanied by a map.

Col. J. C. Fremont* also passed over nearly this same route during the winter of 1853–'54. He crossed the Sierra Blanca through the Sandy Hill Pass; thence his route was not materially different from Captain Gunnison's to the point where the latter left Grand River. Colonel Fremont continued further south, and crossed the Sawatch Mountains south of Gunnison's route. He had with him, as far as the Mormon settlement, Mr. F. W. Egloffstein, as topographer.

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* See letters to the editors of the National Intelligencer, which form House Miscellaneous Document No. 8, second session Thirty-third Congress.

SURVEY FOR A RAILROAD TO THE PACIFIC NEAR THE FORTY-FIRST PARALLEL, BY LIEUT. E. G. BECKWITH, IN 1854.

The report of this route, by Lieutenant Beckwith, forms part of Volume II of the quarto edition of the Pacific Railroad Reports. The topographical maps are in four sheets, on a scale of 12 miles to an inch. The profiles are drawn on a horizontal scale of 16 miles to an inch, the vertical scale being $28\frac{16}{100}$ times larger. This report of Captain Beckwith was also published in House Document No. 129, first session Thirty-third Congress, and was accompanied by a preliminary map on a scale of 50 miles to an inch.

On the 3d of April Lieut. E. G. Beckwith, aided by Mr. F. W. Egloffstein and the surviving assistants of Captain Gunnison, started to examine the practicability of the Wasatch Mountains east of Great Salt Lake.

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AN EXAMINATION TO ASCERTAIN THE MOST PRACTICABLE LOCATION FOR A WAGON ROAD ALONG THE CARSON VALLEY ROUTE, PASSING NEAR LAKE BIGLER,† (CALLED BY FREMONT, IN HIS MAP OF HIS SECOND EXPEDITION, "MOUNTAIN LAKE," AND ON HIS MAP OF THE THIRD EXPEDITION, LAKE BONAPLAND.)

This examination throws much light on the subject of the practicability of the route for a railroad.

The altitudes were determined by an aneroid barometer. The determination of the eastern boundary of California was another object in the examination, and for this purpose the party used an astronomical transit and sextant with chronometers. The report of these operations, by George H. Goddard, accompanies the annual report of the surveyor-general of the State of California, Assembly document No. 5, session of 1856.

SURVEY FOR A RAILROAD ROUTE TO THE PACIFIC, NEAR THE THIRTY-FIFTH PARALLEL, BY CAPT. A. W. WHIPPLE, TOPOGRAPHICAL ENGINEERS.

The final report of Captain Whipple forms Volumes III and IV of the quarto edition of the Pacific Railroad Reports, Senate Ex. Doc. No. 78, House Ex. Doc. No. 91, second session Thirty-third Congress. It is accompanied by a topographical map in two sheets, drawn on a scale of 15 miles to an inch, and a sheet of profiles on a horizontal scale of 15 miles to an inch, and a vertical 50 times the horizontal. There are, besides, geological maps and numerous other illustrations. His preliminary report forms part of House Doc. No. 129, first session Thirty-third Congress. This edition is accompanied by a map in two sheets, and on a scale of 1 to 900,000, and a profile of the route on a horizontal scale of 1 inch to 79,500 feet, and a vertical scale of 1 inch to 3,000 feet.

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† Now known as Lake Tahoe.

Captain Whipple was assisted by Lieut. J. C. Ives, Topographical Engineers; Dr. J. M. Bigelow, surgeon and botanist; Jules Marcou, geologist and mining engineer; Dr. C. B. R. Kennerley, physician and naturalist; A. H. Campbell, principal assistant railroad engineer; H. B. Mollhausen, topographer and artist; Hugh Campbell, assistant astronomer; William White, jr., assistant meteorological observer; Mr. George G. Garner, assistant astronomer; Mr. N. H. Hutton, assistant engineer; John P. Sherburne, assistant meteorological observer; and Mr. T. H. Parke, assistant astronomer and computer. They were provided with a portable transit, sextants, and chronometers, for astronomical observations, and with the other instruments needful for reconnaissances. They were escorted by a company of the Seventh Infantry, under Capt. J. M. Jones, and began the survey with a train of wagons. Lieutenant Ives proceeded, with an astronomical transit and other instruments, from Washington, D. C., to Albuquerque, by way of San Antonio and El Paso, where he joined the party.

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SURVEY FOR A PACIFIC RAILROAD THROUGH THE PASSES OF THE SIERRA NEVADA AND COAST RANGE, BY LIEUT. R. S. WILLIAMSON, TOPOGRAPHICAL ENGINEERS, 1854.

The final report of these surveys and reconnaissances forms Volume V of the quarto edition of the Pacific Railroad Reports. It is accompanied by a general map on a scale of 1 to 600,000; one of certain passes on a scale of 1 to 240,000, and several detailed maps. There are, too, sheets of profiles drawn on a horizontal scale of 1 to 120,000 and a vertical scale five times greater. The report is also accompanied by geological maps and profiles. The report and general map were also in House Document No. 129, first session Thirty-third Congress.

Lieutenant Williamson was assisted by Lieut. J. G. Parke, Topographical Engineers; Lieut. G. B. Anderson, Second Dragoons; Dr. A. L. Heerman, physician and naturalist; Mr. W. P. Blake, geologist; Mr. Isaac W. Smith, civil engineer; Mr. Charles Preuss, topographer; and Mr. Charles Koppel, artist. His escort was commanded by Lieut. G. Stoneman, First Dragoons. Continuous topographical sketches of the routes traversed were taken, and the work checked by astronomical observations with the sextant. Two of the passes were surveyed with chain and spirit level. On the map Lieutenant Williamson embodied some of the explorations of Captain Warner which had not before been published.

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RECONNAISSANCE FOR A RAILROAD ROUTE BETWEEN PIMAS VILLAGE AND EL PASO, BY LIEUT. J. G. PARKE, TOPOGRAPHICAL ENGINEERS, IN 1854.

The report of this reconnaissance forms part of Volume II, quarto edition of the Pacific Railroad Reports. This report is printed in House Ex. Doc. No. 129, first session Thirty-third Congress, and is there accompanied by a map on a scale of 5 miles to an inch, and profile on the same horizontal scale, the vertical being 1,000 feet to an inch.

Lieutenant Parke, assisted by Mr. H. Custer, topographer, and Dr. A. L. Heerman, physician and naturalist, and provided with barometers, odometers, and compass, on the 24th of January, 1854, left San Diego with a party of twenty-three men, exclusive of an escort, under Lieutenant Stoneman, of twenty-eight dragoons

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RECONNAISSANCE FOR A RAILROAD ROUTE FROM EL PASO TO PRESTON, BY BVT. CAPT. JOHN POPE, TOPOGRAPHICAL ENGINEERS, 1854.

The report of this reconnaissance will be found in Volume II of the quarto edition of the Pacific Railroad Reports, and is accompanied by a map, on a scale of 15 miles to an inch, and a profile on the same horizontal scale, the vertical being fifty times greater. The report, with a map and profile, on a scale of 10 miles to an inch, also forms part of House Doc. No. 129, first session Thirty-third Congress.

Capt. J. Pope was assisted by Lieut. Kenner Garrard, First Dragoons; Dr. J. Mitchell, surgeon and naturalist; Mr. C L. Taplin, and J. H. Byrne, with an escort of twenty-five men under Lieut. L. H. Marshall, Third Infantry. The party, including teamsters, etc., numbered seventy-five men. They were provided with sextant, chronometer, odometer, and compasses. The grades were determined by measuring the vertical angle with a theodolite. The expedition left Doña Ana February 12, 1854.

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Captain Pope made additional explorations in the vicinity of the Guadalupe Mountains during the years 1855, 1856, and 1857, while engaged in the experiment for obtaining water by artesian wells, but his final report has not yet been made.

EXPLORATION AND SURVEY FOR A RAILROAD ROUTE FROM BENICIA, CALIFORNIA, TO FORT FILLMORE, NEW MEXICO, BY LIEUT. J. G. PARKE, TOPOGRAPHICAL ENGINEERS, 1854-'55.

The report of these examinations forms part of Volume VII of the quarto edition of the Pacific Railroad Reports, and is accompanied by two topographical maps, on a scale of 12 miles to an inch, and profiles of his routes on the same horizontal scale, and a vertical scale fifty times larger. On the same sheet is a profile of the route from Fulton to San Diego, on a horizontal scale of 36 miles to an inch, and a vertical scale fifty times greater. There are also geological maps and profiles.

Lieutenant Parke was assisted by Mr. Albert H. Campbell, civil engineer; Dr. Thomas Antisell, geologist; and Messrs. Custer and N. H. Hutton, topographers. They were provided with sextants and chronometers, barometers, compasses, and odometers. On the 20th November, 1854, they left Benicia with a party of about thirty persons.

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EXPLORATION AND SURVEY FOR A RAILROAD ROUTE FROM THE SACRAMENTO RIVER TO THE COLUMBIA RIVER, BY LIEUT. R. S. WILLIAMSON, TOPOGRAPHICAL ENGINEERS.

The report of this expedition, owing to the illness of Lieutenant Williamson, was written by Second Lieut. H. L. Abbot, Topographical Engineers. It forms Volume VI of the quarto edition of the Pacific Railroad Reports, and is accompanied by a topographical map, in two sheets, on a scale of 12 miles to an inch, and two sheets of profiles, on the same horizontal scale, but with the vertical scale fifty times greater.

The party consisted of Lieut. R. S. Williamson, Topographical Engineers, assisted by Lieut. H. L. Abbot, Topographical Engineers, with Dr.

J. S. Newberry, as geologist; Dr. E. Sterling, as physician and naturalist; Mr. H. C Fillebrown, as assistant engineer; Mr. C. D. Anderson, as computer; and Mr. John Young, as draughtsman. A light cart was taken for the instruments, but everything else was transported by pack mules. The party was supplied with sextants and chronometers, odometers, compasses, and barometers.

The expedition left Benicia, California, on July 10, 1855, and proceeded up the Sacramento Valley to Fort Reading, crossing the river at Fremont. At the fort it was joined by the escort, consisting of Lieut. H. G. Gibson, Third Artillery; Lieut. G. Crook, Fourth Infantry; Lieut. J. B. Hood, Second Cavalry, and one hundred soldiers

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In making the map of this exploration, Lieutenant Abbot embodied various unpublished military reconnaissances made in Oregon and northern California, which he duly acknowledges. These were: That by Major Alvord, in 1853, from Myrtle Creek, in Umpqua Valley, to Rogue River Valley; that by Mr. G. Gibbs, in 1852, from Humboldt Bay to the head of Scott's River; that of Lieutenant Chandler, in 1856, near the mouth of Rogue River; that of Lieutenant Kautz, in 1854, near Coos Bay; those of Lieutenant Williamson from Yreka, east of Shasta Butte, to Fort Reading; from Yreka to lower Klamath Lake, and from Port Orford to Coquille and Rogue Rivers, made while on military duty in the Department in 1851-'52.

UNITED STATES AND MEXICAN BOUNDARY SURVEYS.

These surveys began in 1849, and continued, with various interruptions, till 1856. During the establishment of the boundary line agreed upon by the treaty of Guadalupe Hidalgo, four different appointments were made of United States commissioner, four of astronomer, and two of surveyor. Delays were caused by these changes, by a want of means to properly carry on the work, and by differences of opinion as to the proper initial point on the Rio Grande.

The following-named reports can be consulted in relation to it:

1st. The reports of the Secretary of the Interior, one dated February 27, 1850, printed Senate Ex. Doc. No. 34, first session Thirty-first Congress;

and another dated July, 1852, which is printed Senate Ex. Doc. No. 119, first session Thirty-second Congress.

These contain various letters from different individuals and sketch maps in reference to the initial points of the boundary line on the Pacific shore, at the juncture of the Gila and Colorado Rivers, and on the Rio Grande.

2d. Extract from a journal of an expedition from San Diego, California, to the Rio Colorado, from September 11 to December 11, 1849, by A W. Whipple, Lieutenant United States Topographical Engineers; printed Senate Ex. Doc. No. 19, second session Thirty-first Congress

3d. Report of Lieut Col. J. D. Graham, Topographical Engineers, Senate Ex. Doc. No. 121, first session Thirty-second Congress.

This is a narative by Colonel Graham of his connection as astronomer with the establishment of this line, and is accompanied by numerous letters from different persons, one of which is Lieutenant Whipple's report to Colonel Graham on the survey of the Gila. This report of Colonel Graham is also accompanied by a "barometric profile of the route from San Antonio via Castorville, Fort Inge, Howard's Spring, Ojo Escondido, Eagle Spring, El Paso del Norte, and Doña Ana, to the copper mines of Santa Rita, in New Mexico, in 1851; from observations by and under the direction of Bvt. Lieut. Col. J. D. Graham, United States Topographical Engineers, assisted by Lieut. W. F. Smith, Togographical Engineers, and Mr. J. Lawson, and computed by Lieut. G. Thom, Topographical Engineers" The profile is on a horizontal scale of 20 miles to an inch, the vertical scale being $105\frac{6}{10}$ times greater.

Colonel Graham acknowledges, in terms of commendation, the aid received by him from Lieutenant Whipple, Topographical Engineers, and Lieutenants Tillinghast and Burnside, U. S. Army.

4th. "*Personal, Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexican Boundary Commission, during the years* 1850-'51-'52, *and* '53. *By John Russell Bartlett, United States Commissioner during that period; in two volumes, with maps and illustrations. Published by D. Appleton & Co., Nos.* 346 *and* 348 *Broadway, New York, and No.* 16 *Little Britain, London*—1854."

In page 11 of the preface to this work, Mr. Bartlett says: "The maps of the survey, as well as the astronomical, magnetic, and meteorological observations, with all that strictly appertains to the running and marking the boundary line, were, by the instructions of the Secretary of the Interior, placed in charge of the surveyor, Bvt. Maj. W. H. Emory, who alone is held responsible for the faithful performance of these duties. From the high character of that officer as an engineer, the public may expect, in proper season, a satisfactory account of his labors in these departments. Some time must elapse before the maps to illustrate the whole boundary from one ocean to the other can be completed; I have therefore been compelled to construct, meanwhile, the map prefixed to this work from my own itinerary and from the most authentic information that could be obtained."

This work contains, among other things of interest, an account of the country south of the boundary, on the route from El Paso via the Guadalupe Pass to Guaymas; and also of a journey through Chihuahua, Coahuila, and New Leon to the Rio Grande.

5th. "Report on the United States and Mexican Boundary Survey," made under the direction of the Secretary of the Interior, by William H. Emory, Major First Cavalry and United States Commissioner. Washington: Cornelius Wendell, printer."

The report of Major Emory was published in 1858, and forms Senate Ex. Doc. No. 108, first session Thirty-fourth Congress, and, with the appendices, makes two volumes. There are four topographical maps on a scale of 1 to 600,000, "showing the boundary line and the country contiguous, as far as information has been obtained from actual survey or reconnaissance." There is also a topographical map on a scale of 1 to 6,000,000, entitled a "Map of the United States and their Territories between the Mississippi River and the Pacific Ocean and part of Mexico, compiled from surveys made under the order of W. H. Emory, Major First Cavalry, United States Commissioner, and from the maps of the Pacific Railroad, General Land Office, and the Coast Survey, projected and drawn under the supervision of Lieut. N. Michler, Topographical Engineers, by Thomas Jekyll, C. E., 1857-'58." This map (of all the country north of the surveys of the Mexican boundary) is a reduction from the map which I have compiled for the Pacific Railroad office.

Major Emory's report is also accompanied by a geological map of the same country, and on the same scale as that just mentioned, prepared by James Hall, assisted by J. P. Leslie, esq. This map is without date.

There is also a barometrical and geological profile along the Rio Grande from its mouth to El Paso, and thence across the country to the Pacific. The report contains numerous illustrations of scenery, and geological, botanical, and zoological plates.

Assistance is acknowledged to have been received in the field from Lieut. A. W. Whipple, Topographical Engineers; Bvt. Capt. E. L. F. Hardcastle, Topographical Engineers; Mr. G. C. Gardner, Dr. C. Parry, Messrs. E. Ingraham, C. Radziminski, Arthur Schott, J. H. Clark, S. W. Jones, E. A. Phillips, J. H. Houston, J. E. Weiss, H. Campbell, F. Wheaton, W. White, and G. G. Garner.

The line, as finally determined and established under the treaty of Guadalupe Hidalgo, extended up the Rio Grande from its mouth to latitude 31° 54′ 40″ north; thence west along that parallel to the meridian of 109°37′ west; thence due north to the Rio San Domingo; thence down that stream to the Gila; thence down the Gila to its mouth; thence in a straight line to the point on the Pacific in latitude 32° 32′ north.

Numerous reconnaissances were made by different parties in going to and from various points on the line; and the Rio Grande was surveyed as far up as the parallel of 32° 22′ north, and a portion of that parallel run by Lieutenant Whipple as directed by Mr. Bartlett, commissioner at the time.

The treaty of 1853, by which the tract of territory known as the Gadsden purchase was acquired from Mexico, changed the boundary line so as to make it commence on the Rio Grande at latitude 31° 47′ north; thence due west 100 miles; thence south to latitude 31° 30′ north; thence due west to the 111th meridian; thence in a straight line to a point on the Colorado 20 miles below its junction with the Gila; thence up the Colorado to the former line.

To establish this boundary Major Emory (then brevet major, Corps Topographical Engineers) was appointed commissioner and astronomer on the part of the United States; and the work was accomplished during the years 1855–'56. Major Emory was assisted in this work by Lieut. N. Michler, Topographical Engineers; Lieut. C. N. Turnbull, Topographical Engineers; Messrs. C. Radziminski, M. T. W. Chandler, J. H. Clark, H. Campbell, W. Emory, M. Von Hippel, C. Weiss, F. Wheaton, A. Schott, J. Houston, D. Hinkle, B. Burns, E. A. Phillips, and J. O'Donoghue. Capt. G. Thom, Topographical Engineers, had charge of the office in computing the work and projecting the maps of both boundary surveys.

SURVEY OF ROAD FROM BIG SIOUX TO MENDOTA, BY BVT. CAPT. J. L. RENO, UNITED STATES ORDNANCE, IN 1853.

Captain Reno was assisted in this survey, which was made with chain and compass, by Mr. James Tilton (now surveyor-general of Washington Territory) and Mr. A. Cross.

The map now in the Topographical Bureau has never been published. The report forms printed House Ex. Doc. No. 97 first session Thirty-third Congress.

EXPLORATIONS OF THE SOURCES OF THE BRAZOS AND BIG WICHITA RIVERS, BY CAPT. R. B. MARCY, FIFTH INFANTRY, IN 1854.

The report of this forms Senate Ex. Doc. No. 60, first session Thirty-fourth Congress. It is accompanied by a map of the region explored, on a scale of 8 miles to an inch. Captain Marcy was accompanied by Major Neighbors, Indian agent, and Dr. G. G. Shumard, geologist, and escorted by forty-five men of the Seventh Infantry, under Lieuts. N. B. Pearce and G. Chapin. An odometer, compass, aneroid barometer, and thermometer composed his main instruments.

The object of the expedition was to find suitable lands to reserve for the Indians.

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No astronomical observations being made, he adopted the positions of Forts Belknap and Phantom Hill, from Johnson's map of Texas.

FUR HUNTERS OF THE FAR WEST, BY ALEXANDER ROSS, IN TWO VOLUMES; PUBLISHED BY SMITH, ELDER & CO. LONDON: 1855.

This book begins with the transfer of Astoria to the British Northwest Company, and gives the history of this company down to its union with the Hudson's Bay Company in 1821, which closes the first volume. The second volume is a narrative of some expeditions conducted by the author for the Hudson's Bay Company in 1825 and previous years. On one of these he led a large trapping party into the Snake country, and visited the sources of Salmon, Malade, Goddin's, and Reid's or Boisé Rivers, giving a very interesting account of much country as yet unexplored by any surveying expedition, and I believe undescribed in any other book. The information concerning it is of great value and interest.

The author, in speaking of the great amount of information required by the members of these fur companies, and the little that has been given to the public, says that it has not been kept secret from design, but merely from inability to make it public.

There are many works of travels and adventures on the prairies mentioned in this memoir, but I have endeavored to refer to most of those containing accurate information of country not covered by the official surveys.

MARCH OF THE COMMAND UNDER COLONEL STEPTOE, FROM FORT LEAVENWORTH TO CALIFORNIA, 1854-'55.

The report of Capt. Rufus Ingalls, who was quartermaster to this command, forms a portion of the printed annual Executive Document of 1855, part two. A map showing the routes of portions of the command from Salt Lake City west is also a part of the same document, and was furnished by Captain Ingalls. The command started from Fort Leavenworth during the first part of June, 1854, and traveled the usual route via Fort Kearny, Fort Laramie, South Pass, and Bear River to Great Salt Lake City, where they spent the winter.

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Lieut. S. Mowry, who accompanied Colonel Steptoe, was detached at Great Salt Lake City in the spring of 1855 to conduct some dragoon recruits and animals by the Santa Fé trail to Fort Téjon, in California.

This duty he performed. His report was rendered to the Adjutant-General, but has not been published. It was not illustrated by any topographical sketches.

SURVEY OF MILITARY ROAD IN OREGON, BY LIEUT. JOHN W. WITHERS, IN 1854.

The map, with descriptive notes, is on file in the Topographical Bureau. It is drawn on a scale of 2 miles to an inch. The road is located along the valley of Umpqua River, between Scottsburg and Myrtle Creek. The report of Lieutenant Withers accompanied the annual report of the Colonel of Topographical Engineers for 1855.

SURVEYS AND RECONNAISSANCE BY LIEUT. G. H. DERBY, TOPOGRAPHICAL ENGINEERS, IN OREGON AND WASHINGTON TERRITORIES, 1854 AND 1855.

The principal of these examinations were for a road from Salem to Astoria, in Oregon, and from Columbia Barracks to Fort Steilacoom, in Washington Territory. The maps are on file in the Topographical Bureau, drawn on a scale of 1 to 48,000. There are also reductions of these (made in the Topographical Bureau) to a scale of 4 miles to an inch. These surveys and maps were made by direction of Maj. H. Bache, Topographical Engineers, by Lieutenant Derby, assisted by Mr. George Gibbs and C. M. Bache. A brief report in relation to these routes will be found in the annual report of the Colonel of Topographical Engineers for 1855.

RECONNAISSANCE OF THE ROUTE OF THE SNAKE RIVER EXPEDITION, BY LIEUT. G. H. MENDELL, TOPOGRAPHICAL ENGINEERS, 1855.

I have never seen Lieutenant Mendell's report. The reconnaissance was probably made by means of compass courses and estimated distances, checked by astronomical observations for latitude. A tracing from his original map is in the Topographical Bureau.

This expedition, consisting of about two companies, all mounted, under the command of Bvt. Maj. G. P. Haller, Fourth Infantry, was organized by General Wool in the summer of 1855, for the purpose of chastising the Indians who had killed some emigrants near Fort Boisé.

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SURVEYS OF ROADS IN MINNESOTA, UNDER CAPT. J. H. SIMPSON, TOPOGRAPHICAL ENGINEERS.

Captain Simpson's annual report for 1855, with a map, on a scale of 24 miles to an inch, showing all the General Government roads under his charge, forms a part of the annual Executive document for that year. One of these roads extends from Point Douglas, on the Mississippi, to the mouth of St. Louis River; another from Point Douglas to Fort Ripley; another from Fort Ripley, on Crow Wing River, to Otter Tail Lake; and another from the Mendota to the mouth of the Big Sioux River. These are the principal roads. The one last mentioned was surveyed by Captain Reno in 1853.

RECONNAISSANCE IN THE DAKOTA OR SIOUX COUNTRY, BY LIEUT. G. K. WARREN, TOPOGRAPHICAL ENGINEERS, IN 1855.

The report of this forms Senate Ex. Doc. No. 76, first session Thirty-fourth Congress. It is accompanied by a map on a scale of 1 to 600,000, giving the detailed topography of the routes explored, and a general map of Nebraska, on a scale of 1 to 3,000,000.

While making this reconnaissance I was attached to the staff of General Harney, commanding Sioux expedition, and was assisted by Mr. P. Carrey and J. H. Snowden. Sketches of routes were also furnished me by Lieut. G. T. Balch, U. S. Ordnance, and Lieut. J. Curtiss, Second Infantry. The instruments used consisted of odometers, compasses, and barometers. I left St. Louis on the 7th of June. * * * Over the routes traveled the distances were measured with an odometer, and maps were made of all the routes traversed.

RECONNAISSANCE OF A ROAD FROM FORT LEAVENWORTH TO THE BIG TIMBERS ON THE ARKANSAS, BY LIEUT. F. T. BRYAN, TOPOGRAPHICAL ENGINEERS, IN 1856.

The map of this is in the Topographical Bureau, but neither it nor the report have been published.

The party under Lieutenant Bryan consisted of Mr. J. Lambert, topographer; Mr. C. Lombard, road surveyor; Mr. C. F. Larned and S. M. Cooper, assistant topographers. Their instruments consisted of compasses and odometers. Having surveyed the route from Fort Leavenworth to Fort Riley, they were joined there by an escort under Maj. L. Armistead.

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RECONNAISSANCE BY LIEUT. J. C. AMORY, FROM FORT GIBSON TO BENT'S FORT, IN 1856.

Lieutenant Amory was attached to the command of Lieutenant-Colonel Morrisson, who left Fort Gibson and traveled up the Verdigris as far as the Kansas boundary. Here they left that river and proceeded northwest, gradually approaching the Arkansas until they struck it at the mouth of Walnut Creek; thence they proceeded over the usual road to Bent's Fort. Their route from Fort Gibson to the mouth of Walnut Creek was through country previously unexplored.

RECONNAISSANCE BY MAJOR MERRILL, UNITED STATES DRAGOONS, IN 1855.

This consists in a sketch of the route of a portion of the Second Dragoons from Fort Belknap direct to Council Grove and Fort Riley.

MAP COMPILED BY LIEUT. I. N. MOORE, UNITED STATES DRAGOONS, IN 1855.

This map embraces the country between the Rio Grande and Pecos, from the thirty-second parallel to the thirty-sixth, and is compiled from examinations, sketches, and notes taken by himself, Major Carlton, Lieutenant Higgins, and other officers of the Army while traversing this region on Indian scouts, etc. The positions of the main points along the Rio Grande, Canadian route, and upper El Paso route are taken from the published maps of the Topographical Engineers.

RECONNAISSANCE BY LIEUT. E. L. HARTZ, EIGHTH INFANTRY, U. S. ARMY, 1856.

Lieutenant Hartz, with a command of three non-commissioned officers and twenty-four men, with two wagons, started on the 16th of August from Fort Davis to intersect the El Paso road. His general course was nearly west, but with many détours to obtain water. He passed through the Carisso Pass, which is difficult for wagons, and struck the El Paso road 25 miles west of Eagle Springs. A map of this route was made by Lieutenant Hartz, on a scale of 1 inch to 5 miles. It is not stated in his report or map what instruments were employed in reconnoitering.

EXPLORATIONS FOR ROAD FROM FORT RILEY TO BRIDGER'S PASS, BY LIEUT. F. T. BRYAN, TOPOGRAPHICAL ENGINEERS, 1856.

The report of this will be found in the annual documents accompanying the President's message for 1857. The original map, on a scale of 1 to 600,000, is in the Topographical Bureau, and was not published with it Lieutenant Bryan was assisted by Mr. J. Lambert, Mr. C. F. Larned, Mr. S. M. Cooper, assistant topographers, and Mr. H. Englemann, as geologist. They were provided with odometers, compasses, barometers, and sextant. They were accompanied by thirty men, and protected by an escort of one company of the Sixth Infantry under Maj. L. A. Armistead.

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SURVEY OF ROAD FROM OMAHA CITY TO FORT KEARNY, BY CAPT. JOHN H. DICKERSON, A. Q. M., IN 1856.

The report of Captain Dickerson is published with the documents accompanying the President's annual message for 1857, but without the map, which is in the Bureau of Topographical Engineers, under the direction of which the survey was made. This survey from Omaha to the Platte, and along that river to Fort Kearny, was made with a chain and compass and spirit level.

A survey was made with compass and odometer of the route up the Loup Fork, on the south side, leaving it near the mouth of Beaver Creek.

RECONNAISSANCE FROM FORT RANDALL TO FORT KEARNY, BY LIEUT. W. D. SMITH, SECOND DRAGOONS, IN 1856.

A reconnaissance was made of this route during the march of a squadron of the Second Dragoons under Lieut. W. D. Smith. The report is accompanied by a sketch map made from the measured distances, but without compass courses. The report has not been printed.

RECONNAISSANCE FROM FORT RIDGELY TO FORT PIERRE, BY CAPT. A. SULLY, SECOND INFANTRY, IN 1856.

A reconnaissance was made of this route by Captain Sully, whose company formed part of the command of Lieutenant-Colonel Abercrombie, in making the movement between these two posts. Topographical sketches were made with a pocket compass and estimated distances. Captain Sully determined the source of the Big Sioux River to be in Lake Kampeska. This map and the report are not yet published.

RECONNAISSANCE ON THE MISSOURI AND YELLOWSTONE RIVERS, BY LIEUT. G. K. WARREN, TOPOGRAPHICAL ENGINEERS, IN 1856.

A map on a scale of 1 to 600,000 has been prepared and the material reduced from it to the Pacific Railroad map. The detailed report and map are not yet published.

On this reconnaissance I was assisted by Mr. N. H. Hutton and Mr. J. H. Snowden, assistant topographers, Dr. and F. V. Hayden, geologist and naturalist, and was provided with an astronomical transit, a sextant, chronometers, barometers, odometers, and compasses. We started on a steamboat from St. Louis, April 16, to join General Harney at Fort Pierre, and on our way made a map of the Missouri from the mouth of the Big Nemeha. At Fort Pierre I received orders from General Harney to proceed on board the American Fur Company's boat *St. Mary* and examine the Missouri River as far as she should go, and then to return down the stream by Mackinac boats. The Missouri River was thus mapped as far up as the mouth of the Big Muddy, 60 miles above Fort Union. The party consisted, in addition to the assistants, of about thirty men, seventeen of whom were enlisted men of the Second Infantry.

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BRIEF STATEMENT OF THE EXPEDITIONS THAT TOOK THE FIELD IN 1857.

The United States astronomical and surveying parties for establishing the boundary line (49th parallel) between the United States and Great Britain, of which Archibald Campbell, esq., was commissioner, and Lieut. J. G. Parke, Topographical Engineers, astronomer, was organized under the State Department and started for the field of operations on the Pacific coast in April, 1857.

The party under Mr. W. H. Nobles, organized in the Interior Department for making a road from Fort Ridgely to the South Pass, examined the route during the summer as far west as the Missouri at the mouth of Crow Creek.

The party under Lieutenant Warren, Topographical Engineers, organized by the War Department, started in June in two divisions—one from Omaha City, the other from Sioux City. They united at the mouth of Loup Fork, examined this stream to its source, and thence proceeded by way of the valley of the Niobrara River to Fort Laramie. Thence they proceeded north, explored the Black Hills, and, returning by way of the Niobrara River examined it to its mouth.

The wagon-road expedition, organized under the Department of the Interior, of which Mr. F. W. Lander was the engineer, made reconnaissances of the mountains between Green River and Bear River.

The wagon-road expedition under Lieutenant Bryan, this year, was confined to routes which he had previously mapped and explored.

The expedition against the Sheyenne Indians, commanded by Colonel Sumner, explored a portion of the country between the Platte and Arkansas Rivers.

The party commanded by Colonel Johnston to survey the southern boundary of Kansas, and of which Mr. J. H. Clark was astronomer and Mr. Weiss surveyor, was organized by the War Department. It accomplished that work and reconnoitered the country south of the line.

The party for constructing a wagon-road from Fort Defiance to the Colorado River was organized by the War Department and placed in charge of Mr. E. F. Beale. He examined the line of the proposed road during the summer and winter.

The party for the construction of a wagon-road from El Paso to Fort Yuma, of which Mr. Leach was superintendent and Mr. N. H. Hutton was engineer, passed the summer and winter in the operation, and have not yet returned.

The expedition of Captain Pope for making of experiments in artesian well-boring is still in the field.

A party under Mr. Major, for establishing that part of the 98th and 100th meridians between the Canadian and Red Rivers, was organized by the Interior Department and is still in the field.

The expedition under Lieutenant Ives for ascertaining the navigability of the Colorado of the Gulf of California, was organized under the War Department and is still in the field.

The Land Office surveys along the whole frontier are advancing steadily, as in former years.

The foregoing is an epitome of the expeditions taken direct from Warren's Memoir, Pacific Railroad Reports, Vol. XI. In Chapter V he gives the method of compiling the map of the territory west of the Mississippi, with a list of the principal longitude determinations. This general map, first published immediately before the outbreak of the war, was drawn and engraved to the scale of 1 to 3,000,000 (1″=47.35 miles) and contained all the then known topographic and general geographic information of this territory, and with revisions was issued up to 1867, when a recompilation was commenced.

NOTE.—As instances, more particularly of general geological exploration work, or publication not appearing on page 499 of House Ex. Doc. 270, Forty-eighth Congress, second session (Venice Geographical Report), notes of which have kindly been furnished by Jules Marcou, the following may be mentioned, which, though not furnishing data valuable for map compilation (especially in original geographical co-ordinates), are of interest at least from a bibliographical point of view:

Gabriel Franchère, 1819–'46–'54.—Narrative of a voyage to the northwest coast of America in the years 1811–'12–'13–'14. First edition (French), Montreal, 1819; second edition (English), New York.

M. Nuttal, 1821.—A journal of travels into the Arkansas Territory during the year 1819.

J. K. Townsend.—Narrative of a journey across the Rocky Mountains to the Columbia River. Philadelphia: 1839.

Prince Maximilian de Wied, Neuwied, 1840.—Voyage in the interior of North America, 1832–'33–'34. Three volumes with atlas. Paris. (Published also in German.)

Duflat de Mofras.—(Exploration du territoire de l'Orégon, des Californies, etc.) Exploration of the Territory of Oregon, of California, etc., 1840–'41–'42, in two volumes, 8°, 1844. Published by order of the King, under the auspices of the President of the Council and the Minister of Foreign Affairs. Vol. I, p. 521, four plates; Vol. II, p. 387, four plates; accompanied by an atlas of twenty-six sheets (maps and plans). On page 475 *et seq.* of Vol. I will be found a list of latitudes and longitudes of eighty-six places, with authorities.

De Smeth (the Jesuit Father), 1846 (?).—Letters upon the Rocky Mountains. (These first appeared in the Annals of the Propaganda at Rome.)

G. F. Ruxton, 1848.—Adventures in Mexico and the Rocky Mountains.

Ferdinand Romer, 1849.—Texas. (Contains a geological and geographical map.)

P. T. Tyson, 1850.—Geology of California. His report forms a part of Senate Ex. Doc. No. 47, Thirty-first Congress, first session, which also contains several maps, especially one by Lieut. (afterwards General) E. O. C. Ord, with two reports of this officer to General Riley.

Jules Marcou, 1855–'58.—Geology of North America, p. 144, with three maps and seven plates. Zurich: 1858. This publication contains a compiled general geologic map of the country west of the Mississippi River (no scale); also a general geological map of New Mexico (compiled), scale 1 to 900,000.

In 1880 General G. K. Warren had proposed to furnish notes of "some interesting early explorations" of which he had learned since his memoir was published (and also additional bibliography), as soon as his duties should permit, which he had not, however, been able to do before his death in 1882.

In the same category are the following voyages and travels, taken from a manuscript kindly furnished by Amos Bowman, now an assistant of the Canadian Geological Survey:

In 1806 Simon Fraser, a partner in the Northwest Company, explored westward from the Red River settlement, reaching Fraser Lake, between the great bend of the Fraser River and the mouth of Skeena River, in latitude 54° N., and established a fort.*

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* See Greenhow's Memoir, p. 155.

David Thompson, a partner and geographer of the Northwest Company, set out from the Selkirk settlement on Lake Winnipeg in 1810, for the purpose of crossing the Rocky Mountains to the Columbia River. In the spring of 1811 he constructed a cedar canoe, near the sources of the Columbia (probably at the boat encampment in latitude 52° N.), and descended that river, arriving on July 15 at Astoria. He was the first white man to descend the northern or upper main branch of the Columbia. Finding the Astor Company already in possession he returned the way he came.*

He made a map of the previously unexplored and unsurveyed Northwest Territory, which is preserved in the Crown lands department of Canada.

In 1824–'25 Dr. McLoughlin established a post at Fort George (Astoria) and at Vancouver.

Rev. Samuel Parker's exploring tour beyond the Rocky Mountains in 1835–'36–'37, with map, is written in narrative, but has separate chapters on geology, zoölogy, ethnology, and climatology. Mr. Parker entered the Rocky Mountains, and traveled by the usual trappers' (afterwards the Oregon emigrant) route via Black Hills, Jackson's Hole, the Three Tetons, Pierre's Hole, Fort Hall, Grande Ronde, and Walla Walla to Vancouver.

In 1841 Sir George Simpson crossed the Rocky Mountains via the Saskatchewan and Kootenay Rivers, and came down the Columbia to the Hudson Bay establishment at Vancouver, of which there is a published account.

McLeod's Santa Fé expedition left Austin, Tex., in June, 1841, and proceeded over the Llano Estacado and was captured by the Mexicans.

Fremont made a fourth expedition in 1848, at his own expense, assisted by the public-spirited citizens of St. Louis, including Dr. George Engleman. He left St. Louis October 9, 1848, and went via Kansas River to headwaters of the Colorado and the Wahsatch Mountains into California by a southern pass.†

Humboldt, in his "Aspects of Nature," attempts to present the progress of discovery in the Far West.

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*See Irving's Astoria, pp. 96, 97.

†See Upham's Life of Fremont. Boston: 1856.

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NOTE.

The authorities consulted, and upon which this memoir of expeditions between 1857 and 1880 depends, are the published reports of the several expeditions and works, communications from Messrs. King, Hayden, Powell, and G. K. Gilbert (the latter regarding Black Hills exploration by Jenney), replies to Engineer Department circular of February 8, 1875, and from notes compiled in the fifth division of the office of the Chief of Engineers, by whose order all the manuscript matter collected at the Engineer Department has been placed in my hands for examination and digest.

In order that a route should be considered as possessed of sufficient geographical information to be embraced in the following lists, especially of expeditions subsequent to the war, the criterion followed has been that there should have been established at its terminal points, or along its course from original and independent observations and computations, latitudes and longitudes, one or both.

Hence it has been necessary to omit many worthy military expeditions of no little magnitude and importance, that have added to the store of general geographical and topographical knowledge, that has often in map compilation been utilized by connecting with known points the geographical co-ordinates of which had been established, as also the great number of scouts, meritorious in themselves, but not provided with the means or instruments for determining independent geographical latitudes and longitudes.

To do full justice to the efforts of the Army, as a fixed, as well as a moving nuclei in the pioneer settlement of our western region would require a special memoir, and while the large number of important military expeditions are not here traced out, as not within the scope of this compilation, yet no one more than the author is alive to the great importance of all these movements, not alone as the bulwark upon which the early settlement has leaned, but as gatherers of facts, topographical detail and allied data. The Army has on one occasion and another threaded nearly every main and minor route in the West and scouted myriads of lesser streams to their very source, thus producing a vast fund of truthful and practical information that in various forms has been available to the Government, the settler, and the public.

It is not by any means certain that my examination has developed all the expeditions that come within the schedule, the available time having been short and my health broken; therefore, conscious of the imperfections, the result is submitted with diffidence, and with the hope that where errors and omissions are found that I may be notified of them.

G. M. W.

Principal Authorities consulted in Preparation of Memoir.

Annual Reports, Chief of Topographical Engineers, 1857 to 1862, inclusive.

Annual Reports, Chief of Engineers, 1866 to date; also manuscript and other maps at Engineer Department.

Professional Papers No. 24, Corps of Engineers, U. S. Army.

Primary Triangulation of the Lake Survey, Comstock.

Published reports and maps of the geological exploration of the 40th parallel.

Published reports and maps, geographical surveys west of the 100th meridian.

Published reports and maps of the geological and geographical survey of the Territories.

Published reports and maps of the geological and geographical survey of the Rocky Mountain region.

Published reports and maps of the geological exploration of the Black Hills.

Annual reports of the General Land Office, 1857 to date.

Annual reports of the Coast Survey from 1852 to date.

Annual reports of the Naval Observatory, and report under Nautical Almanac Office of 1869; total solar eclipse 1869.

Executive documents mentioned under the several headings: Report of the survey of the northern boundary; report of exploring expedition from Santa Fé to junction of Grand and Green Rivers, 1859, Macomb; report of explorations across the Great Basin of Utah, 1859, Simpson; report of Owen's geological survey of Iowa, Wisconsin, and Minnesota; report of exploration of Oregon Territory by M. Duflot de Mofras, two volumes, 1845; Northwestern Wyoming, including Yellowstone National Park, Jones, 1873; Nebraska and Dakota, Warren, 1855 to 1857; military wagon-road from Fort Walla Walla to Fort Benton, Mullen, 1858 to 1862; exploration of Yellowstone River, Reynolds, 1859; Texas boundary, Senate Ex. Doc. No. 70, first session Forty-seventh Congress, geological report, Hayden, Engineer Department, 1859 and 1860; Ives's Colorado River expedition, 1857 and 1858; Barlow and Heap, Yellowstone region, 1871; Ludlow, Black Hills, 1875; Ruffner, Ute country, 1873 and 1874; Raymond, Yukon River, 1869; Symons, Columbia River; Geology of the Black Hills of Dakota, Newton and Jenney, 1880.

Letters of several engineer officers to the Chief of Engineers, from archives of the Department, and maps compiled at headquarters divisions and departments; manuscript notes prepared in Division V, Office of the Chief of Engineers, U. S. Army; summary list of boundaries run by the General Land Office, in manuscript; manuscript maps of Northwest Boundary Survey, from State Department.

From manuscripts and letters kindly furnished by Messrs. Hayden, Powell, King, Hague, Gilbert, the General Land Office, and others.

CHAPTER I.

EXPLORATIONS FROM A. D. 1857 TO OUTBREAK OF WAR OF THE REBELLION.

WAR DEPARTMENT.

EXPLORATION OF LIEUT. G. K. WARREN, T. E., IN 1857. LOUP FORK, BLACK HILLS, BETWEEN FORKS OF SHEYENNE RIVER, NIOBRARA RIVER, ETC.

The survey was made under the direction of Capt. A. A. Humphreys, in charge of Office of Exploration and Survey, and for which the sum of $25,000 was set apart. Organized at Omaha, and left there June 27, 1857. The objects sought were to gain knowledge of the Territories of Nebraska and Dakota generally in both practical and scientific matters, and among the former was specially desired the nature of the routes pursued as to their being favorable or otherwise to the construction of common roads or railroads.

The expedition divided at once into two parts, one going direct to the Loup Fork of the Platte, the other up the east bank of the Missouri to Sioux City, where an escort was obtained, and thence as directly as possible to the rendezvous at the Loup Fork. Thence the whole expedition proceeded up the main Loup Fork to its source, in longitude 104° 35′, in the Great Sand Hills, making occasional side examinations some 10 miles on each side of the river.

Thence the expedition tried to proceed directly north to the Niobrara River, but the sand ridges compelled it to take a westerly course through a country with occasional alkaline and fresh-water lakes, but scantily watered, till it struck the Indian trail between the Platte and Niobrara, in longitude 102° 30′. Thence it easily reached the Niobrara River, which it followed to where the trail turns off to Fort Laramie, and thence to that point, the longitude of which was determined to be 104° 30′.

In two parts the expedition left Fort Laramie September 4, 1857, one portion proceeding down the Niobrara to about longitude 101° 30′, and there awaiting the other, which proceeded nearly due north to the neighborhood of Rawhide Butte, which was examined; thence to the Indian agency of the Dakotas, on the Niobrara, and from there by a well-marked trail to the Old Woman's Fork; down this to the Sheyenne, along this some distance, thence to Beaver Creek, and along the east branch of that into the Black Hills. Entering these from the west the Inyan Kara Creek was reached; thence southeast by a peak named in honor of General Harney to Bear Butte and the North Fork of the Sheyenne; thence southeast to the South Fork of the Sheyenne, where connection was made with the route of 1855; thence up this fork two days, then through a portion of the "Bad Lands" to the White River; thence southerly to the Niobrara River, and thence to the rendezvous with the other party at the mouth of Reunion Creek.

The whole expedition then proceeded down the Niobrara River to the junction of Turtle Creek, when the main party proceeded directly to Fort Randall, while a special party continued the reconnaissance of the river to the Missouri. At Fort Randall a longitude was determined, and thence the expedition went to Sioux City, where it closed.

Lieut. G. K. Warren, T. E., commanded the expedition, escorted by 30 enlisted men of the Second Infantry under Lieut. James McMillan. The civil assistants were J. H. Snowden and P. M. Engel, topographers; Dr. F. V. Hayden, geologist; W. P. C. Carrington, meteorologist; and Dr. S. Moffatt, surgeon.

The instruments were a portable transit of 26 inches focal length, pocket and box chronometers, sextants, prismatic and pocket compasses, odometer, mercurial barometers and thermometers, and a full outfit of everything necessary for collecting and preserving objects of natural history.

Only a preliminary report of Lieutenant Warren to Capt. A. A. Humphreys has been published in the Report of the Secretary of War accompanying the President's Message to Congress at the session beginning December, 1858. A selection from this was published in No. 9, Vol. I, of the publications of the American Geographical and Statistical Society of New

York, November, 1859, and is also quoted by the English traveler, Burton, in his "Journey across the Rocky Mountains to California," published by Harper & Brothers, New York, 1862. A number of these preliminary reports (1 vol , 8°, pp. 173, 1859), printed for special distribution by the War Department, were accompanied by a military map of Nebraska and Dakota by Lieutenant Warren, which embodied his own results and those of earlier explorers, on a scale of 1 to 120,000. This map was published by resolution of the Senate, first session Thirty-fifth Congress.

The above report was reprinted in 1875 (1 vol., 8°, pp. 125).

A letter dated January 29, 1858, by Lieutenant Warren to Senator G. W. Jones, of Iowa, by direction of the Hon. J. B. Floyd, Secretary of War, was also published (8°, pp. 15), with a small sketch map, scale 1 to 6,000,000.

SOUTHERN BOUNDARY OF KANSAS, LIEUT. COL. JOHNSTON, 1857.

This boundary was established by Lieut. Col. Joseph E. Johnston, First Cavalry, under the War Department during the summer and fall of 1857. He was assisted by J. H. Clark, H. Campbell, and J. E. Weyss.

A reconnaissance was also made for a railroad route from the southeast corner of Kansas to the Rio Grande. A practical route was found commencing at Neosho, Mo.; thence southwestwardly, crossing the Grand and Little Verdigris Rivers and the Arkansas at approximate latitude 36° 20′; thence south of west to the Canadian, connecting with Lieutenant Whipple's route of 1853 near the one-hundredth meridian; thence via head of Canadian to Anton Chico on the Pecos; thence westward to Albuquerque, on the Rio Grande. A report to the Secretary of War of the latter appears in House Ex. Doc. No. 103, Thirty-fifth Congress, first session, accompanied by a printed copy of the general map, scale 1 to 1,000,000.

The original maps of this boundary determination, in one general sheet, scale 1 to 1,000,000, and 9 detailed sheets, 8 of which are at scales 1 to 100,000, and one at scale 1 to 25,000, are now on the files of the Engineer Bureau.

From a note indorsed on Map No. IX of the vicinity of the terminal point, scale 1 to 25,000, it would appear that this point, ascertained by assuming the west boundary of Missouri at longitude 94° 38′ 03″.6 west from Greenwich and measuring 462.7 miles, was found upon revision and full comparison of the moon culmination observations, taken at this point, to be 11,582 feet too far west, which places (by this authority) the west boundary of Missouri at 94° 40′ 26″. No field-notes are on record in the Engineer Bureau.

The act of July 8, 1856, authorizing the survey directs the line "to be surveyed and distinctly marked, and a plat of said survey shall be deposited in the office of the Secretary of the Interior, and another plat of said survey shall be deposited in the office of the Secretary of the Territory of Kansas. The sum of $35,400 was appropriated to carry out the above.

EXPEDITION FOR THE EXPLORATION OF THE COLORADO OF THE WEST, BY LIEUT. J. C. IVES, CORPS OF TOPOGRAPHICAL ENGINEERS, 1857-'58.

The work of this expedition was commenced at "Robinson's Landing," near the mouth of the river, on or about December 1, 1857.

The party ascended the river in an iron steamer fifty feet long, constructed in sections, and shipped from the east to the mouth of the river via San Francisco. Fort Yuma was reached January 9, 1858, where the entire party (two sections approaching from San Diego and old Fort Tejon, respectively) were assembled.

The principal object of the expedition was to ascertain how far the river was navigable for steam-boats, and whether it might not prove an avenue for the economical transportation of supplies to newly occupied military posts in Utah and New Mexico.

The steamer exploration was conducted as far as "Explorers' Rock" at foot of Black Cañon, from whence by skiff the head of the cañon was reached, and probably Las Vegas Wash. Here the further exploration of the river was abandoned, a return to the steamer made, the foot of Black Cañon assumed to be the practical head of navigation, and a reconnaissance conducted to connect this point with the road to the Mormon settlements A land party under Lieutenant Tipton also followed the banks of the river from Yuma to Pyramid Cañon. The entire expedition returned to the Mohave villages, where a division was made, a portion returning on the little iron steamer, the *Explorer*, to Fort Yuma; the remainder, including Lieutenant Ives, Dr. Newberry, Messrs Egloffstein, Mollhausen, and Peacock, laborers, packers, and twenty soldiers as escorts under Lieutenant Tipton, took up a further land exploration. This party proceeded to the eastward, reaching by a détour the Grand Cañon at the mouth of Diamond Creek, thence along the Colorado Plateau to the northeast. The Grand Cañon was again pierced at the "Yampais villages," near the mouth of Cataract Creek; thence south and eastwardly San Francisco Mountain was reached, and eastwardly the little Colorado, from whence a northern détour brought them to the Moquis villages; thence eastwardly to old Fort Defiance, where the party was disbanded.

The expedition was in command of Lieut. Joseph C. Ives, Corps of Topographical Engineers, and under the direction of the Office of Explorations and Surveys, Capt A. A. Humphreys in charge. Lieutenant Ives was assisted by Messrs. Egloffstein and C. Bielawski as topographers, Messrs. P. H. Taylor and C. K. Bockert, assistants; Dr. J. S. Newberry, geologist, with Mr. Mollhausen as assistant. The engineer and constructor of the steamer *Explorer* was Mr. A. J. Carroll, with Robinson as pilot. The escort consisted of twenty-five enlisted men under Lieutenant Tipton, Third Artillery. The chief of land transportation was Mr. G. H. Peacock. The party were supplied with astronomical transits, sextants, and chronometers, theodolites and transits, cistern barometers, prismatic clinometer, and pocket compasses, chains, tapes, etc. Transit observations, coupled with occultations for longitude, were made at initial and check points; the latitudes were obtained by daily sextant observations and the elevations by barometric hypsometry. Hydrographic and topographic data were separately recorded. The report was made to the Office of Exploration and Survey and published in 1861 as Senate Ex. Doc., Thirty-sixth Congress, first session. It makes one volume quarto, aggregating 365 pages. It comprises also a geological report by Dr. Newberry, one on botany by Profs. Gray, Torrey, Thurbert, and Dr. Engleman, and one on geology by Prof. S. F. Baird. The appendices are devoted to the discussion of the astronomical and barometrical observations, with lists of distances, latitudes, longitudes, etc., and to the construction of the maps. There are two topographical maps: one from mouth of the Colorado to head of navigation, scale 1 inch to 6 miles; another from head of navigation to Fort Defiance, 1 inch to 12 miles. Upon these maps as a base Dr. Newberry has shown the general geological formations in colors. The report is well illustrated by an abundance of panoramic views, engravings, Indian portraits, and wood-cuts.

The party reached Fort Defiance for disbandment May 23, 1858.

This appears to have been one of the most careful, complete, and interesting of the reconnaissance expeditions prior to the war.

A preliminary report appears in the annual report of Captain Humphreys, in charge of Office of Explorations and Surveys, War Department, 1858, from pages 31 to 42, inclusive.

EXPEDITION FROM SANTA FÉ, N. MEX., TO THE JUNCTION OF THE GREEN AND GRAND RIVERS, BY CAPT. J. N. MACOMB, TOPOGRAPHICAL ENGINEERS, 1859.

The survey was commenced in July, 1859, to develop an unexplored region to the northwest. The route was from Santa Fé to Cañada, and thence crossing the Rio Grande up the valley of the Chama via Abiquiu, the then outpost of civilization in this direction, across the continental divide to the headwaters of the San Juan via "Horse Lakes," crossing the Navajoe and Blanco, reaching Pagosa Springs; thence to the valley of the Rio Dolores, crossing the streams known as Piedras, Los Pinos, Las Animas, La Plata, and Mancos, and thence northwestward to the Grand River, to a point whence could be seen the junction of its valley with that of the Green River. To Ojo Verde the route followed sensibly the old "Spanish Trail."

Returning, a southerly direction was taken till the San Juan was struck, near the mouth of Rio de la San Abaso, the right bank of which was followed up to a crossing opposite Cañon Largo, which cañon was followed up to the divide, which was crossed to the valley of the Rio Grande; thence to the pueblo of Jemez, to the crossing of the Rio Grande at San Domingo, and to Santa Fé.

The expedition was commanded by Capt. J. N. Macomb, Topographical Engineers, the escort a detachment of Company E, Eighth Infantry, by Lieut. M. Cogswell. The civil assistants were: J. S. Newberry, geologist; C. H. Dimmock, topographer; F. P. Fisher, as time and astronomical observer; Messrs. Dorsey and Vail, meteorologists. Captain Macomb was the astronomical observer and computer.

The instruments were sextants and artificial horizons, a refracting telescope of about 6 feet focal length and 4 inches aperture, prismatic and pocket compasses, sidereal chronometers, barometers, and thermometers.

A report was made November, 1860, to Capt. A. A. Humphreys, Topographical Engineers, in charge of Office of Explorations and Surveys, and printed (page 149, Senate Ex. Doc. No. 1, second session Thirty-sixth Congress).

Subsequent duty with the Army in the field prevented a more full report on the part of the officer in command.

A map* of the route was prepared on a scale of 2 inches to 1 mile or 1 to 31,680, a reduction from which was incorporated in the map of explorations and surveys in New Mexico and Utah, 1860, scale 1 inch to 12 miles, constructed and engraved on a steel plate by F. W. von Egloffstein.

The survey was completed in September, 1859.

The Geological Report was published by the Engineer Department, U. S. Army, 1876 (1 vol., 4°, 152 pp.) While the map was engraved in 1860, the publication of this report, in common with others on western surveys, was arrested by the war of the rebellion, each and every available military officer and man being called to the field.

Captain Macomb, while en route east, proceeded to the southwest corner of the then Territory of Kansas and retraced that part of the boundary along the thirty-seventh parallel from the old monument to the one hundred and third meridian, and erected a stone monument at the intersection of the above meridian and parallel in November, 1859.

EXPLORATIONS AND SURVEYS FOR WAGON-ROADS ACROSS THE GREAT BASIN OF UTAH FROM CAMP FLOYD TO GENOA, BY CAPTAIN SIMPSON, T. E., 1859.

This exploration and survey, ordered by Bvt. Brig. Gen. Albert S. Johnson, commanding Department of Utah, and having for its object the discovery of routes across the Great Basin of Utah more direct and practicable than the Fremont route—hitherto believed the only one possible—left Camp Floyd May 3, 1859. No itinerary is given, but the party reached the termination of the westward exploration June 12, started on its return June 24, and reached Camp Floyd August 5, having discovered two practicable emigrant and military roads, either of which shortened the distance between Camp Floyd and Genoa 200 miles.

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*This map contains on its face the latitude and longitude of a number of points determined (astronomically) by the expedition.

The party, in command of Capt. J. H. Simpson, Topographical Engineers, was accompanied by an escort of twenty men commanded by Lieut. Alexander Murray, 10th Infantry, and consisted of Lieut. J. L. Kirby Smith, Topographical Engineers, in charge of observations, with sextant for latitude and time or longitude; Lieut. H. L Putnum, Topographical Engineers, in charge of compass survey of route and topography, observations with astronomical transit for longitude and of dip-circle and magnetometer; Henry Engleman, geological, meteorological, and botanical collector; Charles S. McCarthay, collector of specimens of natural history and taxidermist; C. C. Mills, photographer; Edward Jagiello and William Lee, assistants to astronomer, meteorologist, and photographer; H. V. A. von Beckle, a soldier, as artist to take sketches. Asst. Surg. Joseph C. Bailey accompanied the expedition. The entire party, including the escort and employés, numbered sixty-four persons. The expedition was provided with three sextants, three artificial horizons, one astronomical transit, four chronometers, two barometers, and several prismatic and pocket compasses.

The report of Captain Simpson, made to the Chief of Topographical Engineers, February 5, 1861, is accompanied by reports from his assistants on the topographical, geodetic, magnetic, geological, mineralogical, botanical, ethnological, and pictorial character of the country traversed, by a map drawn by J. P. Mechlin (scale 1 to 1,000,000), by profiles, diagrams, and sketches. An important result of the expedition was the establishment by Captain Simpson of a new and more accurate longitude of Salt Lake City, differing largely from certain previous determinations, which has since been substantially verified by the telegraphic determination of the Coast Survey. The report of Simpson was published by the War Department at the Government Printing Office in 1876, and appears as one volume, quarto, 495 pages, accompanied by maps and other illustrations. There is a geological report by Henry Engleman, one on paleontology by Prof. F. B. Meek, a list of birds by Professor Baird, a chapter on ichthyology by Theodore Gill, with botany by Dr. George Engleman.

The entire report consists of an "Introduction, Report, and Journal" and nineteen appendices. It is accompanied by a map (scale 1 to 1,000,000) of the wagon-roads explored and opened by Captain Simpson, which contains original topographical data of parts of the Great Interior Basin, then (1859) but little known. Captain Simpson in 1858, prior to his western trip, examined and surveyed a new wagon route (the itinerary of which appears in the above volume) from Camp Floyd to Fort Bridger, which was constructed also under his direction, and a report of which appears in Senate Executive Document No. 40, Thirty-fifth Congress, second session.

RECONNAISSANCE, FORT DALLES, OREGON, TO GREAT SALT LAKE VALLEY, LIEUT. JOSEPH DIXON, T. E., 1859.

A command was organized for the purpose of exploring and opening a wagon-road from Fort Dalles, Oregon, on the Columbia River, to Great Salt Lake Valley, by special orders No. 40, Headquarters Department of Oregon, dated April 27, 1859, Brig. Gen. W. S. Harney, commanding. Capt. H. D. Wallen, Fourth U. S. Infantry, was in command of the expedition, and Bvt. Second Lieut. Joseph Dixon, Corps of Topographical Engineers, was assigned to duty with the command.

The route traveled commences at Fort Dalles and runs nearly due south, crossing Deschutes River, at the mouth of Warm Spring Creek, to Crooked River, following the same to its headwaters, and from thence to Lake Harney; from thence northeasterly, crossing the Blue Mountains to Malheur River; crossing which, meandering mountain passes and adjacent valleys, Malheur River is again crossed, to Snake River and along this stream to Raft Creek, which is followed to its source at Cedar Spring; thence crossing the dividing ridge to Bear River, which it crosses near mouth of Roseaux River, and from thence nearly due south to Salt Lake City and Camp Floyd.

Another route commences at Fort Dalles and runs easterly to Umatilla River, which it crosses and follows for about 30 miles, thence southeasterly crossing the Blue Mountains to headwaters of Burnt River, which it follows to its mouth on Snake River; thence to Malheur River where the first route crosses that river the second time.

Another route was traversed by Lieutenant Bonnycastle, of the expedition, from Crooked River to Fort Dalles, crossing the Deschutes at its mouth on the Columbia.

Still another route, by Mr. L. Scholl, was also traveled, from vicinity of the mouth of the Owhyee near where the first route crosses Snake River, following the course of the Owhyee to near mouth of Kearney River, which it follows to its source, thence passing headwaters of Cañon Creek, Bruneau, and Salmon Falls River, etc., to Rock Creek, connecting with first-mentioned route.

The instruments used on this exploration consisted of sextants, chronometers, barometers, compasses, odometers, etc.

The reconnaissance was completed as far as Lake Harney, and on October 20, 1859, the command returned to Fort Vancouver.

The report of Lieutenant Dixon was submitted to the Chief of Topographical Engineers and published in Senate Executive Document No. 1, second session Thirty-sixth Congress, accompanied by a map, scale 1 inch to 20 miles, compiled under the direction of Capt. George Thom, Topographical Engineers.

A general report of this expedition, accompanied by reports of Lieutenant Dixon and Lewis Scholl, guide and topographer, appears as Senate Executive Document No. 34, Thirty-sixth Congress, first session. In the appendices are found (pp. 46–49) tables of latitudes, longitudes, variations of the needle, altitudes, and distances.

SURVEY OF THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, 1857-'61.

STATE DEPARTMENT.

The United States Commission, authorized to determine and mark the boundary line between the United States and the British Possessions, from the crest of the Rocky Mountains to the Pacific Ocean, according to the treaty of June 15, 1846, and to act conjointly with a similar English commission, was created by act of Congress of August 11, 1856.

A commission, consisting of Captains Prevost and Richards, Royal Navy, was appointed by the British Government to determine that part of the line which runs through "the channel which separates the continent from Vancouver's Island."

In the summer of 1858 Col. J. S. Hawkins, Royal Engineers, appointed as British commissioner to determine the land portion of the boundary, arrived with a party organized for field operations. In February, 1857, Mr. Archibald Campbell was appointed commissioner for the United States; Lieut. John G. Parke, Topographical Engineers, chief astronomer and surveyor, and G. Clinton Gardner, assistant astronomer and surveyor. Other members of the expeditionary force were William J. Warren, secretary to the commission; John J. Major, clerk to the chief astronomer; J. S. Harris, general assistant; C. B. R. Kennerly, surgeon and naturalist; Henry Custer and Francis Herbst, topographers; George Gibbs, assistant geologist; J. N. King, quartermaster and commissary; R. V. Peabody, guide and interpreter; Prof. James Nooney and F. Hudson, computers; Charles T. Gardner, surveyor; E. Ross, assistant; and James M. Alden, artist; also, the requisite number of packers, laborers, etc.

The United States Commission was duly organized and repaired to Fuca Straits in the spring of 1857;—from whence, because of the inability to co-operate of the British Commission, the United States Commission established a depot and located an observatory at the western land terminus of the forty-ninth parallel, and continued reconnaissances and explorations in the vicinity of the boundary eastward as long as the season permitted. Four astronomical points on the forty-ninth parallel were determined. A meeting of the joint commission was held in the summer of 1858, and a plan for the field operations for the survey of the land boundary was agreed upon.

The reconnaissance at the close of this season had extended as far east as the valley of the Skagit, and the astronomical observations necessary for marking the three points of the parallel in the valley of the Chiloweyuck were completed.

The following is the work done during season of 1859: Completion of the determination and marking the parallel from three points fixed the previous year; observations for latitude at six stations, between which the parallel has been determined, and seven points marked at crossings of streams; chronometer-trip for difference of longitude between Camp Simiahmoo and Chiloweyuck Depot; longitude determined at two of the latitude stations; triangulation covering an area of 50 square miles; route survey (chained) connecting astronomical stations of about 370 miles; reconnaissance for developing the topography along and adjacent to the boundary line and for communications; magnetic observations at one station and meteorological registers at all the stations occupied.

It is understood that the commission remained in the field during the seasons of 1860 and 1861, but no report is available from which to trace its operations and results for these seasons. The commission passed the winter of 1859–'60 at Fort Colville.

United States troops for the protection of the parties were furnished by General Harney from the Department of Oregon. In 1859 an additional escort, under Captain Archer, met the parties in the valleys of the Similkameen and Okinakane.

The route of the United States Commissioner in 1859 commenced at Fort Langley, thence running down Fraser's River by water to mouth of Chiloweyuck River; thence along the latter to its source, crossing the divide to head of Similkameen River, thence following its northern bank to Lake Osoyas; thence via valley of the Ne-hoi-al-pit-gua River to Fort Colville; thence via Slavoutchas and Chemikana Rivers to the Spokane River; thence to Lewis Fork or Snake River, at the mouth of the Peloux, and to Walla Walla; thence due south to the Umatilla; thence to Fort Dalles; from the Dalles by water to Monticello, thence along the Cowlitz River and the headwaters of the Chehalis to Olympia on Puget Sound.*

The transportation was largely by mules and pack-trains on land, and whale-boats on the water. Bridging streams, corduroying and grading rough roads, with ferryings at river crossings, was constantly done.

The instruments used were astronomical transits, heliotropes, zenith telescopes, transit theodolites, telescopes, sextants, chronometers, magnetic theodolites, dip-circles, compasses, pocket levels, chains, tapes, camera-obscura, barometers, hygrometers, and thermometers.

Monuments marking stations on the parallel were constructed of pyramidal piles of stones 6 to 8 feet high, or earthen mounds, covering wooden posts.

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*This route is indicated in manuscript on a printed map of Oregon and Washington Territories, 1859. Scale 1 to 1,500,000, Bureau of Topographical Engineers.

These stations were established at nearly every accessible point from which the line was ascertained, and traced along vistas crossing valleys and trails. The reconnaissance line connecting stations was 800 miles, embracing an area of 30,000 square miles. Within this space over 800 barometric heights were obtained. The boundary line exceeds 9° in longitude, or about 410 miles, and the amount expended (see Senate Ex. Doc. No. 86, Fortieth Congress) for its survey and demarkation, including the preparation of results, was $569,223.79, or at the rate of $1,388.34 per mile. Magnetic observations were made over an arc of 3° 20′ in latitude, and 4° in longitude.

Reports upon the geology, botany, and natural history of the reconnaissance area were prepared. Glaciers were discovered and perpetual snow found in the cascades (2 feet of snow found on the route in July, 1859). Much of the line ran through a heavy growth of pine and fir, with much fallen timber.

A progress report of the marking of the boundary, made November 12, 1859, appears as Senate Ex. Doc. No. 16, Thirty-sixth Congress, first session. The expenditures made appear in House Ex. Doc. No. 86, Fortieth Congress, second session, in which a letter from Mr. Campbell to the Secretary of State gives data concerning the nature and extent of the services performed, but I have been unable to trace the manuscript of the final report, including that of the chief astronomer and the specialists, which it is believed was made. According to the Journal of the Senate of February 9, 1871, this report was called for by the Senate, but a search of the Senate records, and also those of the State Department, made at my request by Mr. Dwight, librarian of the State Department, remained unavailing on June 15, 1887. Mr. William J. Warren, secretary of the commission, now chief clerk of the Engineer Department, recollects to have seen the manuscript of this report at the office of the Northern Boundary established in 1873, as does also Maj J. F. Gregory, Corps of Engineers, a member of that commission, but it could not be found by Mr. Dwight in the records transmitted at the close of the latter survey to the State Department. The original manuscript maps are on file in the State Department, photographic copies of which were furnished the General Land Office.

Captain Prevost, R. N., visited the 49th parallel in October, 1857, and in absence of Captain Richards proposed to proceed to the determination of the water boundary. He claimed Rosario Straits (the channel nearest the continent), and Mr. Campbell the Canal de Haro (the channel nearest Vancouver's Island), as the boundary channel intended by the treaty. The British commissioner, after correspondence, proposed to compromise by running the boundary through an intermediate channel, thereby securing the island of San Juan to Great Britain, which the United States commissioner declined.

Senate Ex. Doc. No. 29, second session Fortieth Congress, contains the correspondence above referred to; also a geographical memoir of the islands in dispute, and a map and cross-section of the channels.

In pursuance of the fifth section of the act creating the commission the superintendent of the Coast Survey was directed to place the steamer *Active* and brig *Fauntleroy* at the disposal of the commission. Both of these vessels were employed for the survey and soundings of the various channels and islands between the continent and Vancouver's Island, co-operating with Captain Richards of the British surveying steamer *Plumper*, as a result of which a thorough survey of these channels and islands south of the 49th parallel was made during the several seasons, which was shown on the map above mentioned.

Maps.—The following maps were constructed and compiled under the supervision of Archibald Campbell, commissioner, and Lieut. John G. Parke, Topographical Engineers, by Assistants L. D. Williams, Theo. Kolecki, and Ed. Freyhold, in 1866, and found reproduced, as follows:

"Survey of the northwest boundary, 1857–'61, from Point Roberts, along the forty-ninth parallel to the Rocky Mountains between the British Possessions and the United States," fourteen sheets, scale 1 to 60,000, photolithographed on double the scale of the originals; also, maps showing the boundary line from the western coast of the continent to the middle of the channel which separates the continent from Vancouver's Island, and thence southerly through the middle of said channel, etc., to Fuca Straits, scale 1 inch to 4 miles (engraved); also, map embracing the country between the parallels 46° and 49° 30′, and from the Pacific to 110° west longitude (all in Washington Territory), scale 1 inch to 17 miles (photographic copies); also, a series of cross-sections from Vancouver's Island on parallels 49°, 48° 45′, 48° 35′, and 48° 25′, respectively, to the mainland, were also prepared (engraved).

MILITARY ROAD, FORT WALLA WALLA TO FORT BENTON, BY CAPT. MULLAN, 1858-'62.

The purpose of this expedition, which took the field in 1858, was to survey, locate, and build a wagon-road from Fort Benton, on the Missouri, to the Oregon country at Walla Walla, thus completing a northern line of road communication to the Pacific.

The route commenced at Walla Walla and ran northeast to Snake River at the mouth of Palouse Creek, crossing on the way Dry Creek and Ponchet River; along Palouse River, Cow Creek to Aspen Grove; from thence northeast crossing the head of Rock Creek, a tributary of the Oraytayons River, to Hangman's Creek and to Spokane River, which it crossed and followed to Cœur d'Alêne Mission and the river of that name; thence crossing summit of Bitter Root Mountain and striking the source of St. Regis Borgia River, the valley of which and also that of Bitter Root River it follows to Hell's Gate; thence along the Big Blackfoot River to Hell's Gate River; thence along Deer Lodge River; thence northeast over hilly ground to Little Blackfoot, up which and over the west base of the Rocky Mountains at Mullan's Pass to Prickly Pear Creek, which it follows to near its mouth; thence due north to Dearborn River; thence via Bird Tail Rock to Blackfoot Agency on Sun River, and thence northeast to Fort Benton.

The expedition was under the command of Capt John Mullan, Second Artillery. He was assisted by C. R. Howard and Capt. W. W. de Lacey, civil engineers; P. M. Engel, topographical engineer; Theo. Kolecki, topographer; John Weisner, meteorologist, and assistants; G. Sohon, guide and interpreter, and others in various capacities. The military escort consisted of 100 men, detailed from the Third Artillery, at Fort Vancouver, accompanying which were Lieuts. James L. White, H. B. Lyon, and James Howard, Third Artillery. The report made to the Chief of Corps of Topographical Engineers was published as Senate Executive Document No. 43, Thirty-seventh Congress, third session, accompanied by four maps: One, reconnaissance from Fort Dalles via Fort Walla Walla to Fort Taylor, on Snake River, scale 1 to 300,000; one from Fort Taylor to the Cœur d'Alêne Mission, scale 1 to 300,000; one from Cœur d'Alêne Lake to Dearborn River (tributary of the Missouri River), scale 1 to 300,000, and a general map of the entire route, scale 1 to 1,000,000. The field work closed in September, 1862. In the exploration and location of this road distances were measured by the odometer, longitudes determined by lunar culminations, latitudes by polaris and meridian altitudes and prime vertical observations (the astronomical transit and sextant being employed), bearings by the Schmalcalder compass, profiles by the barometer, together with variations of the needle from camp to camp. The resulting latitudes, longitudes, and altitudes appear in an appendix to the above document. Considerable topographical information regarding territory on either side of the route, especially from a reconnaissance northward to Fort Colville, Wash., appears for the first time on the resulting general map. During the Indian difficulties of 1858, Lieutenant Mullan commenced the exploration and location of this road from Fort Dalles as far as Cœur d'Alêne Mission, as acting topographical engineer on the staff of Col. Geo. Wright, Ninth Infantry, and his report forms Senate Executive Document No. 32, Thirty-fifth Congress, second session.

EXPEDITION TO THE HEADWATERS OF THE YELLOWSTONE AND MISSOURI, BY CAPT. W. F. RAYNOLDS, CORPS OF TOPOGRAPHICAL ENGINEERS, 1859-'60.

The expedition started from St. Louis, May 28, 1859, by steamer, passed up the Missouri to Fort Pierre, and left the river at that point June 28, 1859, having for its object the examination of the headwaters of the Yellowstone and Missouri Rivers, and of the mountains in which they have their sources.

Leaving Fort Pierre the expedition went westward, skirting the northern slope of the Black Hills to the waters of the Powder River; down that stream to within 40 miles of the Yellowstone; thence westward to that river, below the mouth of the Big Horn; thence southward to the Platte, by two routes, one up the Big Horn, skirting the eastern base of the Big Horn Mountains, the other from 20 to 50 miles farther east. The expedition wintered at Deer Creek, on the North Platte. From winter quarters to the three forks of the Missouri the expedition was divided. One party passed up the Wind River with the intention of reaching the headwaters of the Yellowstone, but was compelled by impassable mountains to cross to the headwaters of the Columbia, near the sources of the Colorado; thence along the west side to Henry Lake; thence down the Madison to the three forks of the Missouri. The second passed through the valley of the Big Horn to the lower cañon; thence westward, by the Yellowstone and Gallatin of the Missouri to the three forks; thence to the mouth of the Yellowstone by three routes—the first by way of the Yellowstone; the second overland, on the east side of the Missouri to Fort Benton, thence by the Missouri; and the third overland from Fort Benton, following approximately the line separating the waters of the Yellowstone and Missouri Rivers. From the mouth of the Yellowstone part of the expedition descended the Missouri in boats to Omaha, and the remainder reached that place by a route never passed over before on the west side of the Missouri.

The expedition was commanded by Capt. W. F. Raynolds, Corps of Topographical Engineers.

The escort for the year 1859 was commanded by First Lieut. Caleb Smith, Second Infantry. The escort for the year 1860 was commanded by First Lieut. John Mullins, Second Dragoons, and First Lieut. Henry E. Maynadier, Ninth Infantry, was assistant.

Astronomical positions en route were determined with sextant and chronometer The topography was sketched with the use of prismatic compass and odometer The longitude of "winter quarters" was determined by observations of moon culminations with transit instrument.

The report, delayed by the breaking out of the rebellion, was made to the Chief of Engineers in 1867. The narratives of Captain Raynolds and his assistants were published as Ex. Doc. 77, Fortieth Congress, first session (8vo, 174 pages).

A special geological report by F. V. Hayden was printed in 8vo, 174 pages, at the Government Printing Office in 1869. The report (Ex Doc. 77) was accompanied by a topographical map on the scale of 1 to 1,200,000, by profiles and sketches of routes, and by numerous illustrations, and the special geological report contains the above topographical map, geologically colored.

This exploration first pointed out a route for a wagon-road, which was subsequently opened from the Platte to the three forks of the Missouri, skirting the eastern base of the Big Horn Mountains, and first located correctly the Yellowstone River from where it leaves the mountains to the mouth of Powder River. Captain Raynolds was told by his guide, James Bridger, of the latter having visited and seen "burning plains, immense lakes, and boiling springs" near the sources of the Yellowstone, as also the "Two Ocean River;" but impracticable ridges and deep snows prevented the party from penetrating from the Wind River direction the region since so well known as the Yellowstone National Park.

NOTE.—Bridger also gave Lieutenant Gunnison, while the latter was associated with Stansbury on the Salt Lake Survey (1849-'50), a description of the natural wonders of the Upper Yellowstone, mentioning a lake 60 miles long; plains where the ground resounded to the tread of the horses; geysers spouting 70 feet high; waterfalls; mammoth hot, acid, and other springs. (See Gunnison, History of the Mormons, 1852, page 151.)

The following papers accompanying the report have not been published:

Tables of latitudes and chronometer errors.
Tables of meteorological observations and barometrical heights (two routes 1859, and two routes 1860).
Tables of meteorological observations at Deer Creek.
Tables of meteorological observations at Fort Pierre.
Report on Fossil Plants, by Prof. J. S. Newberry.
Report on Fossil Birds, by Dr. Elliott Coues.
Report on Mammals.
Catalogue of Plants, by Dr. George Engleman
Report on Carices, by Prof. Chester Dewey.
List of Mosses and Liverworts, by Professor Sullivan.
List of Shells, by Professor Binney.

The party reached Omaha, where it disbanded, October, 1860.

HARNEY LAKE TO EUGENE CITY, OREGON, LIEUTENANT DIXON, TOPOGRAPHICAL ENGINEERS, 1860.

By special order No. 37, Headquarters Department of Oregon, April 6, 1860, a command was again organized for the purpose of opening a wagon road from Harney Lake to Eugene City, Oregon, in extension of the exploration made in 1859.

The expedition was commanded by Maj. Enoch Steen, First Dragoons; and Bvt. Lieut. Joseph Dixon, Corps of Topographical Engineers, was assigned to duty with it. The instruments used were the same as in 1859.

A preliminary report, dated September 24, 1860, was made of this expedition by Lieutenant Dixon to the Chief of the Corps of Topographical Engineers, and will be found in his annual report for 1860.

A map of this expedition by Lieutenant Dixon, scale 1 to 750,000, is to be found in Senate Executive Document No. 1, Thirty-seventh Congress, second session.

The reconnaissance was commenced May 24, 1860, and on June 16 it had reached Lake Harney. From thence it was continued in a northwesterly direction with satisfactory results for a distance of 105 miles, when, on account of Indian difficulties, it returned to Lake Harney, and September 14, 1860, to Fort Vancouver.

The area traversed by the expeditions of 1859 and 1860 embraces a great portion of the country between latitude 42° and 45° and longitude 117° and 119° W. from Greenwich, independent of the southeasterly routes reaching Great Salt Lake.

UNITED STATES AND TEXAS BOUNDARY COMMISSION; J. H. CLARK, UNITED STATES COMMISSIONER, DEPARTMENT OF THE INTERIOR, 1858, 1859, 1860.

The boundary line is the one-hundredth meridian west from Greenwich, between the main Red River and the parallel of 36° 30′ north latitude; this parallel between the one-hundredth and one hundred and third meridian, the latter meridian between the parallels of 36° 36′ and 32° and this parallel between the one hundred and third meridian and the Rio Grande.

This commission was organized and conducted by instructions of the Secretary of the Interior of July 9, 1858, pursuant to act of June 5, 1858. Mr. J. H. Clark (the commissioner for the United States) was assisted in the astronomic work by H. Campbell and for the topography by J E. Weyss and W. P. Clark.

No corresponding Texas commission was continuously in the field, and the only known published results appear in Senate Executive Document No. 70, Forty-seventh Congress, first session.

This document, which embraces the field-notes of the astronomic and topographic work, is accompanied by fourteen detailed photolithographic maps (incomplete), each showing a portion of the line, one having upon it the scale of 1 inch to 2½ miles, or 1 to 132,000. The general map, scale 1 inch to 15 miles 4,133 feet (reported as lost in the above document), was found and photolithographed at the Engineer Department, the original having passed into the office of the Commissioner of Public Lands. None of the maps are authenticated or approved, and one is missing.

The field work commenced on January 9, 1859, near the junction of the thirty-second parallel with the Rio Grande, connection being had with the longitude determination of the Mexican boundary near El Paso, and terminated September 7, 1860, the winter quarters of the commission being at Fort Smith, Ark. The latitudes of forty-six stations, resulting from zenith telescope and sextant observations, are found on page 143.

Lunar culmination observations for longitude were made near junction of one hundred and third meridian and thirty-second parallel and near northwest corner, results from which were used in the field, but no final longitude computations are given.

The northwest corner was established by the transfer of longitude from the Kansas boundary, checked by a lunar culmination longitude and independent zenith telescope latitude.

The eastern boundary was joined to that part of the one-hundredth meridian between the Red and Canadian Rivers, run (with the assistance of Daniel G. Major, astronomer) by Messrs. Jones and Brown, in 1859, for the Indian Bureau.

That part of the west boundary between, approximately, 33° and 33° 45′ north latitude was not traced and marked on the ground on account of the desert character of this portion of the Staked Plains.

No part of the line was officially agreed upon or accepted by the two Governments. The length of the boundary is about 800 miles, the determination of which, on account of physical obstacles, required a survey of more than 1,400 miles, checked by nearly 4,000 astronomic observations.

The latitude of Fort Cobb was determined, a part of the Pecos meandered, and considerable topography sketched on either side of the line.

The monuments were of cairns of stone or mounds of earth.

The appropriation of $80,000, made for field operations alone, was also available for the office work, so far as continued. The work was transferred to the General Land Office, and suspended on January 21, 1862, with the maps left, as stated, in a partially finished condition.

During the period from 1857 to the outbreak of the war officers of the corps of Topographical Engineers were engaged in the survey, location, and construction of military wagon-roads in the following States and Territories, viz: Minnesota, Kansas, Nebraska, New Mexico, southern and northern Oregon, Washington and Utah Territories.

While geographical data was not the principal object, the survey of each and every road added its details to the first topographical knowledge of a vast expanse of country, while sketches and maps were always available in compilation of general maps issued by the Topographical Bureau.

The Interior Department during this period were also engaged in the construction of what were termed "Pacific wagon roads," of which Albert H. Campbell was superintendent. (See House Ex. Doc. No. 108, Thirty-fifth Congress, second session, and Senate Ex. Doc. No. 36, Thirty-fifth Congress, second session, the latter accompanied by a number of compiled maps.)

The principal therein mentioned are the "Fort Ridgely and South Pass Road," the "Fort Kearney and South Pass and Honey Lake Road," the "El Paso and Fort Yuma Road," and the "Nebraska Road."

The Land Office or planimetric subdivision surveys, necessary for marking the legal townships and other divisions, were carried on steadily in the several States and Territories west of the Mississippi River during this period.

The Coast Survey operations (devoted principally to the hydrography and a narrow strip of topography adjacent to main harbors) commenced on the west coast in the year 1848. Their progress, which is not especially pertinent to this memoir, will be found in the several annual reports of this service.

The wagon-road examined from Fort Defiance to the Colorado River by E. F. Beale, under the War Department, during the summer and winter of 1857-'58, will be found reported upon in House Ex. Doc. 124, Thirty-fifth Congress, first session. This report is accompanied by a map and itinerary from Albuquerque to the Colorado.

The outbreak of the war of the rebellion called all available officers and enlisted men to duty with the army in the field. The officers of Topographical Engineers were one and all called from the scene of their geographical labors in the Far West for actual war military service.

This corps was merged with the present Corps of Engineers in 1863, and no duties of a topographical character were resumed till the close of the war, when, in 1865, such service was first resumed in the Military Division of the Pacific by Major Williamson, as will appear in the succeeding chapter. (See annual reports of the Chief of Topographical Engineers up to 1863, and all reports of the Chief of the Bureau of Exploration and Survey, accompanying the Secretary of War, for reference to details of wagon-roads, compiled maps, and various results of a topographical nature, concluding those of the ante-war period.)

CHAPTER II.

RECONNAISSANCES, EXPLORATIONS, AND SURVEYS, HEADQUARTERS, MILITARY DIVISIONS AND DEPARTMENTS A. D. 1865 TO A. D. 1880.

SUSANVILLE TO FORT BIDWELL, CALIFORNIA, AND FORT KLAMATH; MAJOR WILLIAMSON, CORPS OF ENGINEERS, 1865.

The survey made by order of Maj. Gen. I. McDowell, commanding Department of the Pacific, organized at Fort Crook, and left there July 18, 1865. It had for its object the examination of routes of communication from Susanville, California, to Idaho and Surprise Valley, and from there to Fort Klamath, and the exploration of such unknown localities as might be of military interest, and to report upon sites for military posts which might become necessary for the protection of the increasing settlements and mining interests.

The routes traveled were from Fort Crook to Susanville, to Smoky Creek Depot, to Summit Springs on the Idaho route, to Surprise Valley, and along its west side to Fort Bidwell, where a connection was made with the northeast boundary corner of California, as established by the surveyor-general of California, and Warner's Valley and Mountains located. From Fort Bidwell a route was surveyed across Warner's Range by Lassen's Pass to Pitt River, the south fork of which was explored to its headwaters in the range near Saddle Mountain, which was ascended and its altitude obtained; thence to Madeline Plains and Pass and to Susanville by Pine Creek. From Susanville a more direct route was examined by Eagle Lake across Madeline Plains to the south end of Surprise Valley; thence by its western side to Fort Bidwell; thence by Lassen's Pass to Hot Springs at the head of Goose Lake, to south fork of Sprague River, and down this to Fort Klamath; thence to Lost River, along this to Grass Valley, and thence by the Old Emigrant Trail to Fort Crook.

Maj. R. S. Williamson, Corps of Engineers, commanded the expedition, and Captain Tillinghast the escort. The civil assistants were John D. Hoffman, photographer, and G. S. Demeritt, barometric observer.

The prismatic compass was used for angles, the odometer for distances, and the barometer for altitudes. Latitudes by sextant were observed at nearly every camp.

The report was made to the General Commanding the Department, but was not subsequently printed. It was accompanied by a map on a scale of 1 inch to 3 miles. In 1866 a map of parts of California, Nevada, Oregon, and Idaho was compiled, comprising the results of the expedition, and published with the consent of the Commanding General by Britton and Rey, of San Francisco.

The survey was completed by the return to Fort Crook, September 28, 1865.

RECONNAISSANCE MADE BY MAJ. R. S. WILLIAMSON, CORPS OF ENGINEERS, IN 1866, FROM FORT CHURCHILL TO CAMP McDERMIT, THENCE TO RUBY AND SILVER CITY VIA CAMP LYON AND RETURN TO CHURCHILL.

The survey made by order of General Halleck, organized July 25, 1866, at Fort Churchill, Nevada, to examine the hitherto unknown portions of northern California and Nevada and southern Oregon and Idaho, with the special object of discovering more direct and easy routes of travel.

The route was from Fort Churchill to the bend of the Truckee River, down this river to where it empties into Pyramid Lake.

A curious discovery was here made of the forking of the Truckee, one branch emptying into Pyramid Lake, the second into Winnemucca Lake, some 3 miles distant and 50 feet lower, 15 miles long and 3 wide.

The shore of this lake was followed to its northern extremity; thence the route lay in a northeast direction to Camp McDermit, a number of springs being discovered on the way. From Camp McDermit the usual circuitous trail to Camp Lyon was followed, from whence an examination was made to Ruby City, Silver City, and vicinity, returning to Camp Lyon.

From there a direct route was examined back to Camp McDermit, passing by the forks of the Owyhee River, which flows for many miles through a cañon from 500 to 1,500 feet deep, which can be crossed in but few places. One of these crossings is at the forks, where wagons can ascend and descend. Thence in a southeast direction an elevated plateau was crossed, from the top of which the descent of several thousand feet was made to the valley of Quin's River, where Camp DcDermit is situated. An attempt was made to find a better and more direct route from this camp to Lassen's Meadows, but the country was found to be sandy, with water only at long distances. From Lassen's by another route to Winnemucca Lake and thence to Fort Churchill.

Maj R. S. Williamson, Corps of Engineers, commanded the expedition. There was no commissioned officer commanding the escort, but Lieut. W. H. Heuer, Corps of Engineers, was Major Williamson's assistant. G. C. Demeritt was the meteorologist.

The instruments used were the sextant, prismatic compass, and odometer. Sextant observations were made nearly every night.

The report was made to the assistant adjutant-general, Department of California, accompanied by tables of distances, altitudes, etc., and a topographical sketch. The report was never printed, but a map on a scale of 1 inch to 12 miles was subsequently lithographed by Britten and Rey, of San Francisco. It is now out of print.

INDIAN EXPEDITION FROM FORT RILEY TO FORT DODGE AND FROM FORT HARKER TO DENVER, COLORADO, 1867, UNDER COMMAND OF GEN. W. S. HANCOCK AND BVT. MAJ. GEN. G. A. CUSTER—LIEUT. M. R. BROWN, CORPS OF ENGINEERS.

The route was from Fort Riley via Smoky Valley and Smoky Hill River to Salina, thence to Fort Harker, thence to Fort Zarah, thence along Arkansas River to Fort Larned, thence up Pawnee Fork to Indian Village, thence to Fort Dodge to headquarters of Coon Creek, thence to Fort Larned; from Fort Larned to Walnut Creek, and crossing Smoky Hill River to Old Fort Hayes on Big Creek, thence via Smoky Hill Valley to Fort Harker.

The expedition left Fort Harker again via Smoky Hill River Valley to Fort Hayes; thence along Big Creek to its source; thence to the head of

Castle Rock Creek and Fort Wallace; thence along the South Fork of Smoky Hill River via Big Timber to Cheyenne Wells; thence via Deering's Wells, David's Wells, and Hugo Springs to Willow Springs; thence along Big Sandy Creek to River Bend. From here the command proceeded by two different routes. The first, north by way of Cedar Point, Fairmount, Benham Springs, Bijou, and Kiowa; the second, south via Reed Springs, Bijou Basin at the source of Bijou Creek, and crossing Kiowa River to Denver. A route was also pursued from Fort Wallace along the valley of the Smoky Hill to Chalk Bluff, thence to Castle Rock, thence to Downer's, and along the valley of Smoky Hill River to New Fort Hayes.

Lieutenant Brown had with him on this expedition a sextant, transit, and artificial horizons, and made observations for latitude, longitude, and variation of the needle.

Accompanying his manuscript report, dated Fort Leavenworth, October 19, 1867, to the Chief of Engineers, are tables of distances measured by odometer, detail journal sketches of the country passed over, its topographical and geological character, and information concerning wood, water, and grass.

REPUBLICAN FORK TO ONE HUNDREDTH MERIDIAN, KANSAS PACIFIC RAILROAD, CAPTAIN HOWELL, CORPS OF ENGINEERS, 1868.

A transit and level line with chain measurement was run by Capt. Charles W. Howell, Corps of Engineers, in 1868, from a point on the Kansas Pacific Railroad up the Valley of the Republican Fork (east side) and across the divide to the valley of the Platte, to connect with a monument erected on the Union Pacific Railroad to mark the crossing of the one hundredth meridian west of Greenwich. The topography was sketched in, and Capt. George D. Graham was in charge of the escort, consisting of two non-commissioned officers and ten privates, Tenth Cavalry. The longitude of the terminal point of the survey was determined by observations with a sextant and telegraphic communication with Chicago. The monument was first established by the engineers of the railroad company by measurement from old Fort Kearney, Nebraska.

RECONNAISSANCE IN NORTHERN DAKOTA, BY CAPT. W. J. TWINING, CORPS OF ENGINEERS, 1869.

The survey, made by orders from headquarters Department of Dakota, started July 1, 1869, having for its object a reconnaissance of the part of northern Dakota lying east of longitude 100° 30′.

The surveyed lines were as follows: (1) From Fort Abercrombie to Fort Totten; (2) from Fort Totten to St. Joseph, crossing the head-waters of the western tributaries of Red River, and returning to the west of Devil's Lake; (3) from Fort Totten to Mouse River and Turtle Mountain and return; (4) a direct trail from Fort Totten to the south bend of Mouse River; and (5) from Fort Totten to Georgetown, on the Red River.

The officer in command was Capt. W. J. Twining, Corps of Engineers. The party was escorted, after leaving Fort Totten (September 6), by Lieutenant Lacristo, Twentieth Infantry, thirty men, and four Indian scouts.

The routes traveled were surveyed with a small compass and odometer, and were checked in latitude by frequent astronomical observations.

The report was made to the department commander, February 20, 1870. The map of the reconnaissance, incomplete, was embodied in the maps of northern Dakota. The report, field-notes, and astronomical observations were also used in connection with the work of the United States Northern Boundary Commission (1872–'74).

RECONNAISSANCE OF THE YUKON RIVER, ALASKA, BY CHARLES W. RAYMOND, CAPTAIN OF ENGINEERS, 1869.

The survey was commenced July 1, 1869, having for its object to fix the geographical position of Fort Yukon (latitude 66° 33′ 47″ north, longitude 145° 17′ 47″ west), and generally to gain information concerning northern Alaska, its resources, the disposition of the native tribes, etc.

The following is the itinerary of the route: Sailed from San Francisco April 6, 1869, to Sitka; thence on the *Commodore* to San Michael's Island, Morton Sound, carrying their small stern-wheel steamer *Yukon*, to be used in the ascent of the river of that name, under deck, leaving Sitka May 9.

On July 1 the *Yukon* was launched, and on the 4th the voyage to the upper mouth of the Yukon River commenced. Fort Yukon was reached

July 31 (distance 1,040 miles). This was the first journey by steam that had been made on the Yukon.

On August 28 the return trip was commenced. Anvic River was ascended in canoes to the head of navigation, 50 miles from mouth, thence over a divide a portage was made to the valley of the Golsova Richka, thence over an almost impassable country, arriving September 24 at the native village of Ikikitoik, on the coast of Norton's Sound, whence, on the 5th of October, a messenger was sent to San Michael's Island for assistance, from whence a whale-boat was secured, in which the party were taken to the ship *Commodore*, which sailed for San Francisco and reached there November 6, 1869.

Capt. Charles W. Raymond, Corps of Engineers, commanded the expedition, Mr. John J. Major being assistant. For surveying, prismatic compasses and hand levels were used; for astronomy, a sextant and five chronometers, portable transit, and zenith telescope; for hypsometry, mercurial and aneroid barometers, wet and dry bulb thermometers; magnetic instruments, theodolite magnetometer, and dip-circle.

The report was made to Maj. Gen. H. W. Halleck, commanding Military Division of the Pacific, and was printed as Senate Executive Document No. 12, Forty-second Congress, and was accompanied by a map lithographed by Julius Bien, on a scale of 1 inch to 50,000 feet, or 1 to 600,000.

The geographical co-ordinates of Fort Yukon being determined, it was found to be on United States territory. Possession was taken and the United States flag raised.

EXPEDITION FOR A MILITARY RECONNAISSANCE THROUGH SOUTHERN AND SOUTHEASTERN NEVADA IN 1869.—LIEUTENANT WHEELER, CORPS OF ENGINEERS, U. S. ARMY.

This expedition started from Camp Halleck, Nevada, on the 27th of June, 1869, and had for its object, in accordance with instructions from headquarters Department of California, Brig. Gen. E. O. C. Ord, commanding, a thorough reconnaissance of the country to the south and east of the White Pine Mines, extending, if practicable, to the head of navigation on the Colorado River, with a view to opening a wagon road thereto from the White Pine or Grant mining district; obtaining correct data for a military map of the country, and for the selection of the site or sites for such military post or posts, to cover the mining country south and east of White Pine from hostile Indians, as might be required. Explorations and examinations in reference to the physical geography of the country, its physical resources in wood, water, agricultural, and mineral productions, were required, and notice was also to be taken of the character, habits, and number of Indian tribes, and their disposition toward miners and settlers.

The area embraced by the reconnaissance of this year was 24,428 square miles, including portions of southeastern Nevada and western Utah. The officer in command (Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, chief executive officer and field astronomer) was assisted by an officer of Engineers as assistant executive officer and field astronomer, an assistant surgeon of the Army, one chief topographer, one assistant topographer and photographer, one surveyor and draughtsman, one assistant surveyor and recorder, one collector, one guide, and the requisite number of teamsters, packers, and laborers.

Personnel of expedition.—First Lieut. George M. Wheeler, Corps of Engineers, U. S Army, in command, chief executive officer and field astronomer; First Lieut. D. W. Lockwook, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; John D. Hall, assistant surgeon, U. S. Army; P. W. Hamel, chief topographer; Carl Rahskopff, assistant topographer and photographer; Charles E. Fellerer, assistant topographer and draughtsman; William M. Ord, assistant surveyor and recorder; John Koehler, collector; Henry Butterfield, guide.

The escort consisted of two non-commissioned officers and twenty-five enlisted men, drawn principally from company H, Eighth U. S. Cavalry.

Besides the daily latitudes and chronometric longitudes, by means of which and trigonometric measurements all the lines of survey were checked, it was found practicable to determine, by telegraph, longitudes at the following stations: (1) Camp Halleck, (2) Peko, (3) Elko, (4) Camp Ruby, (5) Camp near Hamilton, and (6) Monte Christo Mill, White Pine district; the value and character of which appear in the preliminary report.

Instruments.—The instruments used were sextants, theodolites for observations upon peaks, and small Casella instruments with Schmackalder compasses for meandering. Comparison of time was had with members of the U S. Coast Survey, and Maj. H. M. Robert, Corps of Engineers, San Francisco, Cal.

Transportation.—The train consisted of thirty-six persons, eight wagons, forty-eight mules, and thirty-one horses. Supplies were provided at specified points, to which they were transported by the above army wagons, from whence, as centers, they were taken when required by pack animals along the routes following trails, or across country.

Reports.—A special report of this reconnaissance was made to General Ord, commanding the Department of California, and printed at San Francisco in 1869 in a folio pamphlet, accompanied by a topographical map, separately issued, on a scale of 1 inch to 12 miles.

This report, with additions, was reprinted in quarto form (pp. 72) and without the map, at the Government Printing Office in Washington, in 1875. On account of absence in the field no annual report was made at the close of the fiscal year 1868–'69 to the Chief of Engineers.

During this survey eighteen mining districts were visited, viz: Cave, White Pine, Robinson, Patterson, Sacramento, Snake, Shoshone, Ely, El Dorado, Yellow Pine, Timber Mountain, Hercules, Tim-pah-ute, Pahranagat, Reveille, Hot Creek, Morey, and Grant, and notice was taken of their character. The examination showed that there were two distinct extended parallel lines of mineral deposits, both bearing southerly to the military road from Mohave to Prescott. The route for a through line of travel, shortest and most practicable for a rail or wagon road, was found to be the one which crosses the Colorado River at the mouth of the Virgin River, furnishing more wood, water, and grass, and having generally less barren land along its way. By this route loaded wagons can reach Camp Toll-Gate from the Central Pacific Railroad in twenty-one days. Four mineral belts, having a general north and south course, are contained in the region traversed, viz, the Hot Creek, Humboldt, Egan, and Schell Creek belts or ranges. The minerals found are gold, silver, copper, lead, antimony, iron, salt, gypsum, alum, and cobalt; silver being the principal one.

The highest mountains are in the Humboldt and Spring Mountain ranges, some of the peaks reaching 12,000 to 13,000 feet. The rivers are the Colorado, Humboldt, and Virgin, and of the numerous smaller streams many become absorbed in the plains.

A large portion of the region observed is unfit, from its mountainous and desert character, for agricultural purposes, and, where cultivation is possible it must be with irrigation usually. Timber and game are not abundant, and in portions of the valleys water and grass are scarce. The timber for use is white and yellow pine; the principal forage, bunch grass. Herds of cattle range in the principal valleys.

Besides the mining settlements or camps, seven Mormon settlements were encountered along the route surveyed. Indians of the following tribes, to the number of about 2,500, were found within the limits of the survey, viz: Shoshones, Gosiutes, Snakes, Pahvants, Utes, and Pah-Utes.

About 5 miles from where Muddy Creek enters Virgin River is a large deposit of rock salt, known as Salt Mountain. On the left bank of the Virgin, about 8 miles from its entrance into the Colorado, is a salt mine yielding 80 per cent. of salt; the yield of the mountain being 90 per cent. On an extensive mesa, near the mouth of the Virgin, there is a salt well, and saline water is found in pools along the river wash.

A cave in Cave Valley, 3,000 feet in extent, is found near the Patterson mining district.

The Colorado River formed the southern limit of the survey, and was noticed, with reference to practicability of navigation, at Black and El Dorado Cañons, and other points. It was found to be navigable at all seasons as far as El Dorado Cañon, above which point, until obstructions are removed, navigation is dangerous as far as it may ever be carried, viz, to the foot of the Grand Cañon. The part of the Colorado River touched upon was afterward traversed in boats during the exploration of the Grand Cañon in 1871.

This survey discovered that the body of water known as Preuss Lake in the memoirs of Fremont's explorations is the reservoir into which Sevier River empties, and, instead of being in Nevada, lies wholly in Utah. It is now known as Sevier Lake, and, with Salt, Utah, and Owen's Lakes, lies within the great interior basin embracing portions of California, Nevada, and Utah, the waters of which find no outlet to the ocean.

Field work terminated on the 28th of November, nearly six months having been occupied in preliminary and actual observations.

The reductions, necessary upon which the maps were based were made at San Francisco, California, at the headquarters of the Department of California, where the reports were also prepared.

Results.—The principal result of this reconnaissance was the topographic data gathered over an area of 24,428 square miles, and published in preliminary and also final form, the latter appearing on regular atlas sheet, 48 D, 49, 57, 58, 59, and 66. Many new latitudes, longitudes, and altitudes were added to those hitherto existing.

This reconnaissance, based principally on meander methods checked by principal and intermediate astronomic determinations (of the former of which there were six stations), was the precursor of more elaborate reconnaissance work in 1871 and subsequent years, until the introduction of triangulation methods in 1873, that subsequently were carried to the establishment of a complete trigonometric basis for the detailed topography in 1874 and subsequently.

RECONNAISSANCES IN MONTANA AND DAKOTA TERRITORIES, BY CAPT. D. P. HEAP, CORPS OF ENGINEERS, 1870.

Capt. D. P. Heap, Corps of Engineers, as engineer officer of the Department of Dakota in 1870, surveyed the trails from Pembina to Fort Totten, and from Fort Ransom to Fort Wadsworth. He also approximately determined the forty-ninth parallel and marked it from Red River to Pembina, and later in the season made a short reconnaissance of the country near the mouth of the Yellowstone, commencing at Fort Buford, thence up the Yellowstone for 50 miles and return; thence west between the Yellowstone and Missouri, a distance of 40 miles, turning north and striking the Missouri; thence southeast, reaching the outward trail at Nelson's Springs, returning to Buford by the outward route.

Mr. King acted as Captain Heap's assistant in these surveys, except the last, when Mr. Sturgis was engaged.

The instruments used were odometer, compass, chain, sextant, pocket chronometer, and engineer's transit. The distance traveled was about 184 miles. A report and map of the last reconnaissance, on a scale of 1 inch to 2 miles, were forwarded to department headquarters.

YELLOWSTONE EXPEDITION OF 1870, LIEUT. G. C. DOANE, U. S. ARMY.

Lieutenant Doane, in August, 1870, in accordance with instructions from headquarters military district of Montana, with one sergeant and four privates of Company F, Second Cavalry, escorted the surveyor-general of Montana (H. D. Washburn) and eight others to the falls, lakes, and hot springs and geysers of the Yellowstone.

While this expedition does not answer to the criterion of those coming within the scope of the memoir (no latitudes or longitudes having been determined), yet it is introduced as a link in the chain of exploratory endeavor that led to the discovery, exploration, location, survey, and physical examination of that wonderful region now known as the Yellowstone National Park, the probable existence of which was first made known to the scientific world by Captain Raynolds, of the Topographical Engineers, in his report on the exploration of the Yellowstone, published in 1868. This party started from Fort Ellis August 22 on the direct road to the Yellowstone River, which was reached near Butler's Ranch. The valley of the river was then followed to the "Great Falls," thence to Yellowstone Lake, thence via head of Yellowstone and Snake Rivers to Firehole River, a tributary of the Madison, which was followed to near the upper settlements, Lieutenant Doane reaching Fort Ellis in return via Sterling.

A descriptive report by Lieutenant Doane appears as Senate Ex. Doc. No. 51, Forty-first Congress, third session. The information gathered by him was also presented to the Philosophical Society of Washington during the winter of 1870-'71, by Prof. S. F. Baird, and doubtless stimulated the further exploration of this region during the season of 1871 by Prof. F. V. Hayden and party, under the Interior Department, and Captains Barlow and Heap, under the Engineer Department.

RECONNAISSANCE OF THE UPPER YELLOWSTONE, BY CAPT. J. W. BARLOW, CORPS OF ENGINEERS, AND CAPT. D. P. HEAP, CORPS OF ENGINEERS, 1871.

By order of Lieut. Gen. P. H. Sheridan, commanding Military Division of the Missouri, the survey took the field at Fort Ellis, Mont., July 16, 1871, having for its object the examination of the sources of the Yellowstone, Missouri and Snake Rivers, for the purpose of verifying the reports of extraordinary phenomena existing in that region. Crossing the Bozeman Divide it proceeded up the valley of the Yellowstone, discovering and examining the remarkable system of hot springs near the mouth of Gardner's River; thence the Great Falls, the Boiling Mud Springs and the Yellowstone Lake were visited; thence west to the wonderful geyser basin on Fire Hole River, a tributary of the Missouri; thence up the valley and across to the Yellowstone Basin. The western shore of the Yellowstone Lake was meandered, and then the party turned southward to the sources of the Snake River; thence eastward to the Yellowstone, down this valley to the lake, the eastern shore of which was surveyed; thence to the Great Falls on the east side; thence a detour to the east fork of the Yellowstone, which was descended to its mouth. Recrossing the Yellowstone the party returned to Fort Ellis, and disbanded September 1, 1871.

The expedition was in command of Capt. J. W. Barlow, Corps of Engineers, who was assisted by Capt. D. P. Heap, Corps of Engineers. The civil assistants were W. H. Wood and H. G. Prout, topographers; Thomas J. Hine, photographer. The small cavalry escort was commanded by Capt. G. L. Tyler.

The instruments were sextants, chronometers, barometers, compasses, and odometers.

The report forms Senate Ex. Doc. No. 66, second session Forty-second Congress, and is accompanied by a map of the route traversed on a scale of 1 to 300,000.

EXPLORATION IN UINTAH MOUNTAINS, UTAH, BY CAPT. W. A. JONES, CORPS OF ENGINEERS, 1871.

The object of this expedition, as determined by the instructions from headquarters Department of the Platte, was as follows:

(1) To ascertain the character and extent of the valleys of the streams and their adaptability to cultivation or grazing.

(2) To ascertain the character of the timber, its amount, location, and the feasibility of getting it to the railroad.

(3) If possible, to find a wagon road from Fort Bridger to the Uintah Indian Agency.

(4) If practicable, to examine the country on Green River with reference to the large mineral deposits reported there.

Generally, to give all useful information concerning the country examined, which is now comparatively unknown.

The party left Omaha June 11, 1871, and arrived at Fort Bridger June 29, proceeding south along the west branch of Smith's Fork (9 miles distant), thence ascending this stream 24 miles, thence to Gilbert's Pass, thence eastward 12 miles to the headwaters of a branch of Lake Fork called Big Spring Creek, which was followed for 12 miles to within 14 miles of its mouth on the Uintah River. After examination and survey in this vicinity the Uintah Valley Agency, on the North Uintah River, was reached via the valley of this stream.

From thence northeast across Tau-a-wah to Ashley Creek, tributaries of Green River; thence northerly to near the summit of the mountains; thence northwesterly via the heads of Hunting-Ground Creek, Sheep Creek, and Burnt Fork to Henry's Fork, near boundary between Utah and Wyoming; thence northwesterly through the "Bridger Bad Lands" to Sage Creek, northerly along valley of Cottonwood Creek, and due westerly across to Smith's Fork, arriving at Bridger August 19, 1871.

The country was minutely and carefully examined on either hand from the route pursued. On account of the poor character of the transportation furnished it was found impracticable to examine the Green River country as had been anticipated. The expedition was in command of Capt. W. A. Jones, Corps of Engineers, assisted by one topographer and one flagman, and with an escort of one corporal and six men, under Lieut. W. W. Wood, Thirteenth Infantry.

A practicable wagon route was found from Fort Bridger to the Uintah Valley Agency via the pass at the head of the main branch of Smith's Fork, discovered by Lieutenant-Colonel Gilbert, Seventh Infantry. The funds available admitted of only a simple reconnaissance.

The report on this reconnaissance appears as Appendix A A of the Annual Report of the Chief of Engineers for 1872, accompanying which a map was prepared of the "Uintah Mountains and vicinity," scale 1 to 627,264, drawn by L. von Froben, 1872.

RECONNAISSANCES BY CAPTAIN HEAP, 1872.

In 1872 Captain Heap made a reconnaissance of the right bank of the Missouri from Fort Rice to the mouth of Heart River, and surveys of the roads or trails from Fort Rice to the Northern Pacific Railroad crossing of the James River, and from there to Fort Abercrombie.

The instruments employed were of a similar character to those used by Captain Heap in 1870. Captain Heap, during same year, also reconnoitered the country between Beaver Dam and Buck Creeks, including that portion between these streams above and below present site of Fort Abraham Lincoln. A report and map (scale 1 inch to 4,000 feet) were forwarded to department headquarters. The instruments used were sextant, transit, and chain.

RECONNAISSANCE OF THE YELLOWSTONE AND MUSCLESHELL RIVERS, BY MAJ. J. W. BARLOW, CORPS OF ENGINEERS, 1872.

Major Barlow, assisted by Second Lieut. Henry A. Irgens, accompanied the Northern Pacific Railroad engineers in their surveys in 1872 eastward from Fort Ellis, which they left July 27, to the Yellowstone, thence after a few days' work northward to the Muscleshell, up this valley, across the Belt Range, and down Sixteen-Mile Creek to the Missouri. Maj. J. W. Barlow, Corps of Engineers, commanded the expedition.

The escort of three hundred and seventy-six men, cavalry and infantry, was commanded by Bvt. Col. E. M. Baker, major Second Cavalry. The survey disbanded at Fort Ellis about September 29, 1872.

The report was published in Ex. Doc. No. 16, third session Forty-third Congress. A map (scale 1 to 1,200,000) of the country and a survey of the camp where an Indian battle occurred were made, but not published with the report.

SURVEY OF THE YELLOWSTONE RIVER FROM FORT BUFORD TO A POINT TEN MILES ABOVE POWDER RIVER, BY CAPT. WILLIAM LUDLOW, CORPS OF ENGINEERS, JULY, 1873.

This reconnaissance was made in connection with the movements of the Yellowstone expedition of that year. Boats loaded with stores ascended the Yellowstone 85 miles to Glendine Creek, the point near which the Northern Pacific Railroad survey line struck the river, and Captain Ludlow, after departure of the expedition from Glendine Creek, overtook it 10 miles above the mouth of Powder River. The river was carefully mapped by means of compass bearings and estimated distances checked by daily observations with sextant and chronometer. The expedition which Captain Ludlow accompanied consisted of six companies of the Sixth Infantry, commanded by Capt. H. S. Hawkins, Sixth Infantry. A report and map (on a scale of 1 inch to 4 miles) were forwarded to department headquarters.

The astronomical determinations will be found of record at the headquarters of the department at St. Paul.

LAVA BEDS, CAPT. G. J. LYDECKER, CORPS OF ENGINEERS, 1873.

Captain Lydecker made a reconnaissance of the lava beds during the Modoc campaign in northern California in April and May, 1873.

The preliminary report was made to the commanding general of the division, together with sketches and stereoscopic views, and subsequently a general map (showing position of Jack's stronghold, lake shore and country between Hospital Rock and General Gillem's camp, scale 1 inch to 1 mile) was prepared and forwarded to the Engineer Department. Mention of this reconnaissance appears in Captain Lydecker's annual report. (See Annual Report Chief of Engineers, 1873, Appendix FF.)

UTE COUNTRY EXPLORATION, BY LIEUT. E. H. RUFFNER, CORPS OF ENGINEERS, 1873.

This exploration was organized by command of Brigadier-General Pope, commanding Department of the Platte. The expedition left Pueblo, Colo. (the longitude of which was determined by telegraph), May 7, 1873, and ran a line to Fort Garland, Colo., thence across the San Luis Valley and up the Rio Grande to its source, and down the Animas River. Retracing the line to the vicinity of longitude 107° the Pacific Divide was again crossed, the Lake Fork of the Grand River was followed down to its grand cañon, thence east via Los Pinos Agency and Cochetopa Pass to the San Luis Park, where the first line was joined at Del Norte.

Refitting at Fort Garland the expedition was continued over the Cochetopa Pass, up Taylor River and its tributaries, across the Red Mountain Pass to the head of the Arkansas River, and down it to Cañon City, Colo. A side line was run through Puncho Pass, ending at Fort Garland, to connect with the Land Office surveys in San Luis Park. This expedition was the outgrowth of the disturbed relations between the Uncompahgre Utes and the miners of the so-called San Juan region, the ascertaining of the position of the eastern boundary of the Indian reservation (107° west of Greenwich) being the principal object, which was supplemented by an examination of the various approaches from the Arkansas to the Ute country.

The personnel was as follows: Assistant Engineer H. G. Prout (in charge of field work); assistant engineer, James Bassett; recorder, Samuel Anstey; recorder, D. W. Campbell; geologist, F. Hawn; assistant geologist, L. Hawn; photographer, T. Hines and two sergeants of the Engineer Battalion. A small escort from Company F, Eighth Cavalry, commanded by a sergeant, accompanied the first part of the exploration, and Lieutenant De Lancy, with a detachment from Company D, Fifteenth Infantry, escorted the second party.

The line was run by theodolite, the angles being referred to meridians determined nightly; the distance was ascertained by the use of a stadia, and this is believed to be the first time this method has been used in mountain work. A report made to the Chief of Engineers of this exploration, accompanied by a lithographed map on a scale of 1 to 500,000, was printed in Executive document No. 193, Forty-third Congress, first session, House of Representatives, and separately as a pamphlet by the Engineer Department in 1874.

The expedition disbanded at Pueblo October 4, 1873.

Photographic copies of forty-six detail sheets (scale 1 to 50,000) are on files of the Engineer Department.

In appendixes to this report are found tables of distances with astronomically determined positions and altitudes.

RECONNAISSANCE OF NORTHWESTERN WYOMING, INCLUDING THE YELLOWSTONE NATIONAL PARK, BY CAPT. W. A. JONES, CORPS OF ENGINEERS, 1873.

The expedition, which took the field at Fort Bridger, Wyo., in June, 1873, had for its object "the reconnaissance of the country about the headwaters of the Snake, Green, Big Horn, Gray Bull, Clark's Fork, and Yellowstone Rivers;" also to find, if possible, a good route from the south, via the Wind River Valley and Upper Yellowstone, to the Yellowstone National Park and Montana. The route traversed was: leaving Fort Bridger June 12; thence northward to Camp Brown; thence northward across the Owl Creek Mountains into the valley of the Big Horn as far as the Stinking Water River; thence westward across the South Shoshone Mountains to Yellowstone Lake; thence northward, a portion of the expedition going to Fort Ellis, Mont., and making a wide detour to the westward, visiting all the noted phenomena in the park; thence southeast via the head of Wind River to Camp Brown, where the expedition disbanded.

Capt. W. A. Jones, Corps of Engineers, commanded the expedition, and Capt. Henry E. Noyes the escort, of Company I, Second Cavalry, and fifteen Shoshone Indians, who were accompanied by their families.

The assistants were Prof. T. B. Comstock, geologist; Dr. C. C. Parry, botanist and meteorologist; Assistant Surg. C. L. Heizman, U. S. Army, chemist; Second Lieut. S. E. Blunt, Thirteenth Infantry, astronomer; Second Lieut. R. H. Young, Fourth Infantry, acting assistant quartermaster and acting commissary of subsistence; Louis von Froben and Paul Le Hardy, topographers.

The instruments were one large transit theodolite, one small transit theodolite, one chain, three odometers, pocket compasses, one reflecting circle, one sextant, two box and two pocket chronometers, two mercurial and two aneroid barometers, ordinary pocket maximum and minimum and radiation thermometers, and one medical test chest, with apparatus for the field analysis of waters and gases.

The report was made to Brig. Gen. E. O. C. Ord, commanding Department of the Platte, and with the maps form House of Representatives

Executive Document No. 285, first session Forty-third Congress; also House of Representatives Bill No. 2854, first session Forty-third Congress. The former document with additions, including geological report by Professor Comstock, was republished by the War Department in 1875 (1 vol., 8°, pp. 331, with maps and sketches).

The much-doubted "two-ocean water" was discovered where one stream forms the common source of two, running respectively to the Atlantic and Pacific flowing waters.

A very easy pass was found at the head of Wind River, thus opening a route to Montana from the southeast via Wind River and the Yellowstone National Park, the distance from Point of Rocks, Wyo., to Yellowstone Lake being 289 miles, and to Fort Ellis 437 miles.

The reconnaissance was completed in September, 1873.

FORT GARLAND TO FORT WINGATE, LIEUTENANTS RUFFNER AND ANDERSON, 1874.

Lieut E. H. Ruffner states that in June, 1874, Lieut. G B. Anderson, Sixth Cavalry, was detailed from Fort Lyon, Colo., to conduct a survey for a direct wagon route from Fort Garland, Colo., to Fort Wingate, N. Mex. A small detachment of Company M, Sixth Cavalry, accompanied the party, which consisted, in addition to Lieutenant Anderson, of Assistant Engineer D. W. Campbell and Recorder Samuel Anstey.

The instrumental work was done by azimuth and stadia, as in the prior surveys of this office. The line was run southwest from Fort Garland, the instrumental line commencing at a point on the land surveys at the junction of the Conejos River and Rio San Antonio. Two lines were thus carried across the high mountain spur separating the waters of the Conejos and the Rio Chama, one of the tributaries of the Rio Grande, during the month of July.

The report of Lieutenant Ruffner on the results of this examination and survey, accompanied by that of Lieutenant Anderson, is found in House Executive Document No. 172, Forty-fourth Congress, first session (with map, scale 1 to 1,000,000).

An "atlas of detail sheets" (fourteen in number; scale, 1 to 50,000) remain as originals on the files of the Engineer Department.

RECONNAISSANCE OF THE BLACK HILLS, CAPT. WILLIAM LUDLOW, CORPS OF ENGINEERS, 1874.

The expedition under command of Lieut. Col. G. A. Custer was organized in pursuance of special orders No. 117, Headquarters Department of Dakota, June 8, 1874, and had for its purpose the reconnoitering of a route from Fort Abraham Lincoln to Bear Butte, in the Black Hills, and exploring the country south, southeast, and southwest of that point.

The expedition consisted of ten companies of cavalry, two of infantry, and a number of Indian scouts, in all about 1,000 men, one guide, interpreters, and teamsters. Captain Ludlow was detailed as its engineer officer.

The line of reconnaissance (1,204 miles in length) commenced July 2, moving southwestwardly toward the bend of Heart River; thence across the north fork of the Cannon Ball; thence across the south fork, called also Cedar Creek; thence over the Belle Pierres Hills; thence into the valley of the North Fork of Grand River; following this valley for a distance, the trail bore to the southwest, across several bends of the South Fork of Grand River, to a camp on a small branch of the Little Missouri; from this point (called Prospect Valley) the trail led around the northern extremity of the Short Pine Hills, into the valley of the Little Missouri; thence southeasterly in the direction of Bear Butte, camp was made on a small branch of the Belle Fourche, the valley of which stream was reached at a point 292 miles from Fort Lincoln; thence by Redwater Creek, a tributary of Belle Fourche, into the Black Hills; thence to Myan Kara Creek, after the peak of that name, which was here ascended, and near the source of which exploring parties were sent out in various directions; thence camp was made in Castle Valley Creek; thence southeasterly to an unnamed creek (from whence Harney Peak was ascended); from this point reconnaissances were made to the south and southeast, toward the plains, rendezvous being again made in the heart of the Black Hills. On August 6 camp was broken for the return trip, which followed partly the incoming route, to determine the practicability of a road northward through the hills, emerging near Bear Butte. Castle Valley and Elkhorn Prairie were retraversed, whence the plains were reached, and a trail reconnoitered over a different route in 1875, returning to Fort Lincoln (see pp. 1128 and 1129, Annual Report Chief of Engineers), which point was reached August 30, the sixtieth day of the trip.

Captain Ludlow was assisted by W. H. Wood, topographer, and a detachment of Engineer soldiers. Prof. W. H. Winchell was geologist; Dr. Williams, surgeon, U. S Army; George Bird Grinnell, paleontologist and zoologist; a photographer also accompanied the party.

The instruments used were odometers, prismatic compasses, mean solar chronometers, barometers and thermometers, a Wurdemann transit, and a sextant.

The general topography along all routes and at all points visited was carefully recorded and the lines checked by astronomical latitudes and points in the hills checked from a measured base by trigonometric means.

A preliminary report of this expedition was made to the Chief of Engineers, and appears in his Annual Report for 1874 (Appendix KK). A subsequent report, including summaries of distances, latitudes, longitudes, and altitudes, and the result of geological examinations of W. H. Winchell, State geologist of Minnesota, and upon paleontological observations by George Bird Grinnell, representing Prof. O. C. Marsh, appears as Appendix PP, Annual Report Chief of Engineers for 1875. This report also, accompanied by maps, was subsequently reproduced in quarto in 1875 (pp. 121).

The latter document is accompanied by a map of the reconnaissance (scale 1 inch to 12 miles); one of the Black Hills, topographical (scale 1 inch to 3 miles), and a geological map, based on the same.

RECONNAISSANCE FROM CARROLL, MONTANA, TO THE YELLOWSTONE NATIONAL PARK AND RETURN, BY CAPT. W. LUDLOW, CORPS OF ENGINEERS, 1875.

The reconnaissance commenced at Carroll, Mont., July 13, 1875; thence the Carroll road was surveyed to Camp Baker, Mont.; thence to Fort Ellis; thence through Bozeman Pass and up the Yellowstone River to the Yellowstone Park, and return by same route to Ellis August 31; thence to the South Fork of Deep Creek; thence down the South Fork of the Musselshell to the forks; thence along the Carroll road to Armelis Creek. From this point an examination of the Judith basin was made by Lieutenant Thompson, under direction of Captain Ludlow; thence to Carroll, September 19, 1875.

Captain Ludlow commanded the expedition, assisted by Second Lieut. R. E. Thompson, Sixth Infantry. The escort from Carroll to Baker was

10 men, Second Cavalry, under command of Second Lieut. C. F. Roe, Second Cavalry, and from Ellis to Carroll of 2 non-commissioned officers and 8 men of Second Cavalry. The civil assistants were W. H. Wood and Edwin Ludlow, topographers; G. B. Grinnell, paleontologist and zoologist; Edward S. Dana, geologist, besides his detachment of engineer soldiers; and Charles Reynolds, hunter and guide.

The instruments used were transit, chain, sextant, reflecting circle, prismatic compass, odometers, and chronometers.

The report was accompanied by a map of the reconnaissance on a scale of 1 inch to 6 miles. The published report (Appendix NN, Report Chief of Engineers, 1876) is illustrated by three maps—of the reconnaissance, 1 inch to 12 miles; of the Judith Basin, 1 inch to 6 miles; and of the Geyser basin, 1 inch to 6 miles. This report was also separately published in quarto, 155 pages, in 1876.

BIG HORN AND YELLOWSTONE EXPEDITION, CAPT. W. S. STANTON, CORPS OF ENGINEERS, 1876.

This expedition, of fifteen companies of cavalry, five of infantry, one hundred and five wagons, and six hundred pack-mules, commanded in person by General George Crook, was organized at Fort Fetterman in May, 1876.

The expedition left Fetterman May 29, marching northward on the old Montana road, camping first on Sage Creek; thence on branch of Cheyenne; thence across two tributaries to headwaters of this stream; thence to Dry Fork of Powder River; thence to Clear Fork of Powder River; thence via old Fort Phil Kearney to camp on Little Piney Creek; thence to Hay Creek; thence to mouth of Prairie Dog Creek; thence returning along this creek, reaching camp on Goose Creek; thence to Rosebud Creek, where a successful engagement was had with the Sioux Indians; thence to a small stream in vicinity of Tongue River; thence by a devious route to new rendezvous camp on Goose Creek; thence to Camp Cloud Peak, on same stream; thence to main Fort Smith road, near Fort Phil Kearney, returning by the outward route and reaching Fort Fetterman June 21.

Captain Stanton, engineer officer to the expedition, was assisted by Mr. R. F. Koehneman, draughtsman and topographer; Private Henry Kehl, general service, and two infantry soldiers.

The instruments employed were sextants and chronometers for difference of time and latitude, mercurial and cistern barometers, prismatic compass and odometers. Careful topographical sketches of country adjoining the route were made.

A report of the reconnaissance will be found as Appendix PP, Annual Report Chief of Engineers, 1876, and it is also mentioned in Appendix QQ, Annual Report Chief of Engineers, 1877.

CAMPAIGN AGAINST THE HOSTILE SIOUX, LIEUT. E. MAGUIRE, ENGINEER OFFICER, 1876.

The expedition organized in the Department of Dakota was in command of Brig. Gen. A. H. Terry, and to which Lieutenant Maguire, U. S. Engineers, was attached as chief engineer.

It left Fort Abraham Lincoln May 17, 1876, marching almost due west to Heart River; thence to Sweet Brier Creek; thence to Crow's Nest, or Buzzard's Roost Butte; thence to Big Muddy Creek; thence via Big Muddy Valley to Thinfaced Woman's Creek; thence to north fork of Heart River; thence to valley of Powder River; thence to valley of Davis Creek; thence to the Little Missouri; thence via Sentinel Buttes to Beaver Creek; thence via head of Cabin Creek to O'Fallon's Creek; thence to Powder River; and thence to the Yellowstone—a total distance of 318½ miles.

The command with which Lieutenant Maguire moved was transferred by steamer up the Yellowstone, to near the mouth of the Big Horn, where the march to the Little Big Horn commenced, which was reached about 9 miles above its mouth, near the scene of the Custer massacre, which battlefield was mapped.

A return march was made to the Yellowstone, and a reconnaissance carried up the valley of the Rosebud and via Tongue River to Pumpkin Creek; thence to the valley of Powder River via a tributary of the Mizpah, and thence again to the Yellowstone, from whence movements were made in different directions. Astronomical observations, necessarily interrupted by the specially military necessities of the campaign, requiring moving by pack train at a moment's notice in any direction, without intervals of repose, were taken at a number of points, results from which appear on pages 1359 and 1360, Annual Report Chief of Engineers, 1877.

The instruments used were chronometers and sextants, with artificial horizons.

Transportation was both by wagon and pack-train. The elevations are barometric; the measurements are odometric.

Lieutenant Maguire was assisted by Second Lieut. E. J. McClernand, Second Cavalry, and Mr. W. H. Wood. His report appears as Appendix PP of Annual Report Chief of Engineers, 1877.

The original map, now on the files of the Engineer Bureau, drawn by Sergt. James E. Wilson, Battalion of Engineers, is to the scale of 1 inch to 12 miles.

RECONNAISSANCE OF ROUTES IN WYOMING, BY CAPT. W. S. STANTON, CORPS OF ENGINEERS, 1877.

The parties took the field at Cheyenne, Wyo., July 11, and proceeded first to Fort Laramie, 88 miles; thence to Hat Creek, 60 miles; thence to Deadwood, 126 miles; thence to Fort McKinney, 197 miles; thence to Fort Fetterman, 91 miles; thence to Rock Creek Station, Union Pacific Railroad, 83 miles; thence to Laramie Peak, 45 miles; thence to Fort Laramie, 60 miles; thence to Camp Robinson, 73 miles; thence to Deadwood, 157 miles; thence to Custer City, 55 miles; thence to Hat Creek, 87 miles; thence to Camp Robinson, 53 miles; thence to Sidney Barracks, 120 miles; where disbandment was made November 3.

The length of the reconnaissance was 1,328 miles. Forty-four latitudes and longitudes were determined, twenty-two magnetic declinations, and two hundred and seventy-one barometric altitudes.

The expedition was in command of Captain Stanton, who was assisted by Lieutenant Swigert, Second Cavalry; Lieut. Henry Seton, Mr. R. F. Koehsman, draughtsman and topographer; 10 enlisted men, one of whom acted as photographer. An escort of 1 sergeant and 9 men from Fort Laramie, and a like number from Camp Robinson, accompanied the expedition.

The instruments employed were sextants, chronometers, prismatic compass, cistern and aneroid barometers, and odometers.

Independent of latitude and longitude determinations by Captain Stanton, as well as magnetic variations, careful topographic sketches of country adjacent to the routes was recorded, and the usual hypsometric observations taken for altitudes.

The report of this extended instrumental reconnaissance will be found as Appendix RR, Annual Report of the Chief of Engineers for 1878, p. 1705 It is accompanied by a sketch map of the routes (scale 1 to 900,000).

The result of his explorations was availed of by Captain Stanton in compilation of a military map of the Department of the Platte.

The engineer officers at headquarters military divisions and departments have, from time to time, made surveys of military reservations and of wagon-roads, prior to the construction of the latter, the results of which appear in the Annual Reports of the Chief of Engineers; or, if unpublished, in the archives of the Engineer Department or at the headquarters offices respectively. It has been impossible to make an exhaustive study of these separate surveys, and doubtless some established latitudes and longitudes have been missed which would be developed upon a more complete and extended search, which should be done, when final working tabulated lists of latitudes and longitudes shall be made up, weighted and graded according to precision and reliability, with description of monuments, and with full bibliographical references.

The following are the authorities available for the compilation of a standard official list of latitudes and longitudes west of the Mississippi River:

1. Annual reports of Chief of Topographical Engineers (Graham, Lee, Poe); 1860, p. 341; 1860-'61, pp. 554 and 571.
2. Annual Reports Chief of Engineers U. S. Army to date (Lockwood, Bailey, Ruffner, Wheeler, Wisner, Ruffner, Hoffman, Major, Greene, Barlow, Safford, Maguire, and others); 1860-'61, pp. 576 and 581; 1866, p. 48; 1870, p. 546; 1873, p. 681; 1874, pt. 2, pp. 432 and 610-620; 1877, p. – ; 1879, p. —; 1881, Vol. III, p. 2844; 1882, pt. 3, p. 2633, and elsewhere.
3. U. S. Coast and Geodetic Survey to date (various observers).
4. U. S. Geographical Surveys. annual reports 1875 to 1879, inclusive; 1875, p. 11; 1876, pp. 6-35; 1877, pp. 1214-1217; 1878, pp. 6-14; 1879, pp. 114-122; 1880, p. 35.
5. Tables of geographic positions, etc., U. S. Geographic Surveys, 1885 (Wheeler, Lockwood, Hoxie, Marshall, Kampff, Safford, Clark, Austin, Eastman, Wheeler, and Roberts).
6. U S. Geographical Survey Reports, Vol. I, especially App. A, and Vol. II, pp. 486-491.
7. Vol I, Reports of fortieth parallel, p. 766.
8. Astronomic report, 1874; preliminary report, 4°, 1869; distances, etc., 4°, 1878; U. S. Geographic Surveys.
9. Hayden reports, Bull., Vol. III, No. 3, p. 713, 1877; annual reports 1872, p. 796, and annual report 1876, p. 463.
10. Final report Lake Survey (Professional Papers, Corps of Engineers, No. 24; Comstock, Adams, Lockwood, Price, Ruffner, Wheeler, Wisner, Maguire, and others).
11. General Land Office for State and Territorial boundaries.

12. Texas and United States (Clark). Senate Ex. Doc. No. 70, Forty-seventh Congress, first session.
13. United States and Mexican boundary reports (Emory, Whipple, and Michler).
14. United States and Northwestern boundary (Parke and Gardner). MSS. in State Department archives.
15. United States and Northern Boundary report (Twining, Gregory, Greene, and Boss); p. 198.
16. Warren, Vol. XI, Pacific Railroad reports.
17. Naval Observatory, annual report 1871, p. xvi and others.
18. Reports on transit of Venus and eclipse expeditions (Harkness, Newcomb, and others).
19. Yukon River (Raymond and Major); Jones, Wyoming (Blunt and Hitt); Mullan's wagon road, p. 360 (Wiesner and Kolecki); Ives, Colorado River; Simpson, Great Basin; Ludlow, Black Hills; Stanton, Nebraska; Livermore in Western Texas (unpublished), and others.
20. General records of the Engineer Department (see among others 305 and 2139 of 1879, 651 and 2664 of 1881, 3476, 4032 and 4900 of 1882).
21. General records of the Geological Survey (probably).

CHAPTER III.

GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS UNDER THE WAR AND INTERIOR DEPARTMENTS, 1865 TO 1880.

WAR DEPARTMENT.

GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL. (KING.)

This expedition first took the field in 1867, and continued its observations therein during the seasons of 1868, 1869, 1870, 1871, and 1872.

The object of the exploration, as determined by the instructions of General Humphreys, Chief of Engineers (see Appendix V, Annual Report Chief of Engineers, 1869), was "to examine and describe the geological structure, geographical condition, and natural resources of a belt of country extending from the one hundred and twentieth meridian eastward to the one hundred and fifth meridian of longitude, along the fortieth parallel of latitude, with sufficient expanses north and south to include the lines of the Central and Union Pacific Railroads, and as much more as may be consistent with accuracy and a proper progress."

To "examine all rock formations, mountain ranges, detrital plains, mines, coal deposits, soils, minerals, ores, saline and alkaline deposits."

To "collect material for detailed maps of the chief mining districts, coal fields, salt basins, etc., as well as also for a topographic map of the region traversed, and to conduct a systematic series of barometric and thermometric observations, with constant study of the atmospheric conditions bearing upon the subject of refraction and evaporation."

To "make collections in botany and zoology, with a view to a memoir on these subjects, illustrating the occurrence and distribution of plants and animals."

The Union and Central Pacific Railroads were used as the base lines of operations, and thence north and south, generally to distances not exceeding 40 or 50 miles, such routes as were found necessary to reach the points occupied for geological or other purposes were visited.

The area embraced was about 86,390 square miles.*

EXPEDITION OF 1867.

The area embraced during this season was bounded by the one hundred and twentieth meridian on the west and 117° 30′ on the east, and latitude 39° 3′ north and 41° north, in western Nevada.

The expedition took the field in July 27, disbanding at Virginia City December 15, 1867.

During the succeeding winter investigations by Mr. King and one assistant on the Comstock Lode were prosecuted. A statement of progress for this season is found in Annual Report Chief of Engineers, 1868, pages 76 to 77.

The instruments employed for the topographic field work were zenith telescopes for latitude, 8 and 6 inch Wurdemann theodolites, each reading to 10″, for triangulation, and a zenith sextant and chronometers, and 4″ gradienter for topographic details, steel tapes and chains, cistern barometers and hygrometers.

The transportation consisted of army wagons, saddle animals, either riding mules or horses, and pack-mules.

The personnel was as follows: Clarence King, geologist in charge; James D. Hague, assistant geologist; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist, volunteer; James T. Gardner, chief topographer; H. Custer, assistant topographer; F. A. Clark, assistant topographer; Sereno Watson, assistant topographer; W. W. Bailey, botanist; Robert Ridgway, zoologist; T. H. O'Sullivan, photographer.†

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*This area is shown on the general sketch map of the fortieth parallel atlas, and colored on each edition of the Annual Progress Chart of United States Geographical Surveys.

†The lists of personnel do not include such assistants as geological collectors, barometer observers, and persons employed from time to time as general assistants.

The following extract from a letter from Mr. King serves as a general reference to the principal field assistants, the class of work of each, with mention also of the published results:

"I can say to you, in general, that the geological work was under my own personal direction; that I was assisted in this department by Arnold Hague and S. F. Emmons; that the mining geology was executed in conjunction with myself by James D. Hague. The topographical work was under the general direction of James T. Gardner, who executed the road triangulation on which the map is

The escort consisted of 20 mounted enlisted men, with the proper number of non-commissioned officers, the necessary camp equipage, transportation, and subsistence, and also medical attendance. Supplies were also authorized to be purchased from the Quartermaster and Commissary Departments.

SEASON OF 1868.

The field observations required along the belt in question, commencing April 15, were carried until October 15 eastward, nearly as far as the Great Salt Lake, and to the westward limit of its immediate desert, making a belt of 100 miles wide and 500 miles long in Nevada and western Utah, with preliminary explorations in vicinity of Mono Lake, California, and continuation of investigation of the Comstock Lode.

The personnel was as follows: Clarence King, geologist in charge; James D Hague, assistant geologist; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist; James T. Gardner, chief topographer; H. Custer, assistant topographer; A D. Wilson, assistant topographer; F. A. Clark, assistant topographer; Sereno Watson, botanist; Robert Ridgway, zoologist; T H. O'Sullivan, photographer.*

The escort consisted of one sergeant, three corporals, one bugler, and fourteen privates, Troop H, Eighth Cavalry.

SEASON OF 1869.

The season's labors were commenced May 1, and disbandment was had in September.

The area occupied was in the vicinity of Great Salt Lake, and adjacent to mountain ranges in Utah and to the eastward as far as the Green River Divide between 111° to 114° west longitude, and 40° to 42° north latitude.

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based, and measured the astronomical and check bases. The topographical assistants were A. D. Wilson, F. A. Clark, and Henry Custer.

"The legend sheet of the main atlas, the title-page of the mining atlas, and the title-pages of the various volumes, give in full the authorship of the publications of the survey."

*Work carried on in three parties in charge, respectively, of Messrs. King, Arnold Hague, and Emmons. James D. Hague conducted the investigation of mining districts of Nevada and Colorado, in preparation for Volume III on Mining Industry.

A reference to the progress for this season appears in Annual Report Chief of Engineers, 1870, page 87, Vol. III. The first of the quarto series was put to press during the winter of 1869 and 1870.

The following constituted the personnel: Clarence King, geologist in charge; James D. Hague, assistant geologist; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist; James T. Gardner, chief topographer; A. D. Wilson, assistant topographer; F. A. Clark, assistant topographer; Sereno Watson, botanist; Robert Ridgway, zoologist; T. H. O'Sullivan, photographer.[*]

There was also an escort of one sergeant, one corporal, and nine men, Company H, Eighth Cavalry, and ten men (all mounted), Company I, Ninth Infantry.

SEASON OF 1870.

The field period, extending from August 12 to November 15, was used in completing vacant spaces in the 1869 work, and special observations in volcanic and glacial phenomena in northern California, Oregon, and Washington Territory.

The personnel was as follows: Clarence King, geologist in charge; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist; James T. Gardner, chief topographer; A. D. Wilson, assistant topographer; F. A. Clark, assistant topographer.

An escort of one non-commissioned officer and two privates, Company D, Twenty-third Infantry, and such transportation as required and could be spared, was furnished by the military authorities.[†]

Only a commencement was made in this work, which was intended to furnish monographs on the volcanoes, but was never carried to completion.

A progress report appears as Appendix ZZ, Annual Report Chief of Engineers, 1871.

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[*] Work carried on in three parties in charge, respectively, of Messrs. King, Arnold Hague, and Emmons.

[†] Preliminary examination of the volcanoes of the Pacific coast, Lassen's Peak, Mount Shasta in California, Mount Hood in Oregon, Mount Rainier in Washington Territory.

SEASON OF 1871.

The main exploration was continued to the eastward of longitude 111° west in Wyoming, northern Colorado, and a part of Utah, including the Uintah Mountains. The full complement of topographical work was prevented by forest fires of great extent. Volume III, quarto reports, appeared during 1871.

The personnel was as follows: Clarence King, geologist in charge; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist; James T. Gardner, chief topographer; A. D. Wilson, assistant topographer; F. A. Clark, assistant topographer.

The escort consisted of one sergeant, one corporal, and thirteen privates (mounted). Forage from the quartermaster's department for not exceeding forty animals was supplied.*

SEASON OF 1872.

During this field year the unfinished geologic and topographic observations in Wyoming and northern Colorado were completed, with a review of the whole field of exploration from the 105th to the 122d meridian, and further study of extinct volcanoes and glacial phenomena.

The party disbanded on November 13.

Omissions were supplied north of Humboldt River as far east as Humboldt Wells, and field work carried to the region east of the North Platte.

Special observations were conducted in the Sierra Nevada, and at and about Mount Humphreys and the San Francisco Mountain region of the Colorado plateau.

The following was the personnel: Clarence King, geologist in charge; Arnold Hague, assistant geologist; S. F. Emmons, assistant geologist; James T. Gardner, chief topographer; A. D. Wilson, assistant topographer; F. A. Clark, assistant topographer.

An escort of one sergeant and nine men of Company A, Second Cavalry, was detailed to accompany the party of Mr. Emmons.†

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* The work was carried on in two parties under the charge of Messrs. Hague and Emmons, respectively, the former taking the eastern, the latter the western portion of the region embraced.

† The work was carried on in two parties under the charge of Messrs. Hague and Emmons, respectively, the former taking the eastern, the latter the western portion of the region.

Statement of progress for this year is found in Appendix DD and DD^2, Annual Report, Chief of Engineers, 1873.

Mr. King alone in 1873 made a field geological review between September 2 and December 13 of the archæan formations as well as classification of the important mining districts visited.

The balance of the year was taken up in office work by himself, two geological assistants, one topographer, one clerk, and one microscopist.

The office work,* with two geological assistants, one topographer, one clerk, and one microscopist, continued during the years 1874 to 1878, and Mr. King's services in connection with this duty terminated January 30, 1879, while the publication of Vol. VII, the last of the quarto series, is announced in the Annual Report Chief of Engineers for 1880. The main results connected with this work are seven quarto volumes and one atlas.

This atlas contains ten sheets, five alone showing topography proper,† while the geological representations are found in colors upon the above topographic sheets in contours as a base.

Contributions from Messrs. J. D. and Arnold Hague, Emmons, Watson, Eaton, Meek, Hall, Whitfield, Ridgway, Marsh, and Zirckel appear in the several volumes other than No. I, by Mr. King. Volume III (Mining Industry) was issued in 1870, V. (Botany) in 1871, VI (Microscopic Petrography) in 1876, II and IV (Descriptive Geology and Ornithology and Paleontology) in 1877, I (Systematic Geology) in 1878, and VII (Odontornithes) in 1880.‡

The only published geographical co-ordinates are seven latitudes, found in appendix to Volume I, page 765.

It appears that the latitudes and longitudes of three stations (Verdi, Salt Lake, and Sherman) by the U. S. Coast Survey were utilized.

The following main or initial astronomical stations of the U. S. Geographical Survey fall within the fortieth parallel:

(1) Virginia City, (2) Austin, (3) Carlin, and (4) Winnemucca, Nev.;

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* Reports of office progress toward completion appear as appendices to Annual Report Chief of Engineers, as follows: EE 1874, KK 1875, II 1876, MM 1877, and MM 1878.

† The hill work of the topographic sheets, instead of hachures, is represented by brush shading with an oblique light.

‡ A reference to progress and results of this work may be found in House Ex. Doc. No. 88, Forty-fifth Congress, second session.

(5) Ogden, Utah; (6) Green River, (7)* Fort Steele, (8) Laramie, and (9) Cheyenne, Wyo.

Various altitudes are found on the maps, but no distances are given in figures. The methods employed for establishing the field data, upon which the topographic maps are based, is described by Mr. James T. Gardner, pages 764 to 769, appendix to Volume I, Systematic Geology.

The many collections in mineralogy, paleontology, and other branches of natural history were, upon the conclusion of the investigations, transferred finally to the National Museum.

The original field and manuscript records remain a part of the archives of the Engineer Department.

The following is a brief list of maps and reports resulting from this exploration:

MAPS.

1. General atlas. (Scales 1 inch to 60 miles and 1 inch to 4 miles.)	
1. General and preliminary	1
2. Topographic	5
3. Geologic	5
4. Sections	1
2. Atlas with Volume III (geological and mining maps):	
Geologic	3
Miscellaneous	3
Sections	7
Total	25

REPORTS.

1. Annuals separately published	4
2. Monographs, quarto	7
Total	11

The area examined and mapped was 86,390 square miles.

EXPEDITION FOR EXPLORATIONS AND SURVEYS IN NEVADA, CALIFORNIA, UTAH, AND ARIZONA, IN 1871, FIRST LIEUT. GEORGE M. WHEELER, CORPS OF ENGINEERS, COMMANDING.

This expedition took the field at Halleck Station, Nevada, May 3, 1871. Its main purpose, under detailed instructions from Brig. Gen. A. A. Humphreys, Chief of Engineers, was to obtain correct topographical knowledge of the country traversed and to prepare accurate maps of the region entered. Other objects of the survey were to gather as much information as possible relating to the physical features of the country; the number, habits, and disposition of the Indians; the selection of sites for military operations or occupation; facilities for making rail or common roads; to make such examinations as were justifiable from their importance of the mineral resources of the region; and to note the climate, geological formations, areas valuable for agricultural and grazing purposes, and the relative proportions of woodland, water, and other qualities.

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* Connection was made with this station (see Annual Report Chief of Engineers, 1872, p. 1266).

The latitude and longitude of as many important points as possible were also to be determined.

The area embraced was 72,250 square miles, including portions of central, southern, and southwestern Nevada; eastern California; southwestern Utah; northwestern, central, and southern Arizona. The area of the expedition of 1869 was again entered along certain lines.

The following personnel constituted the expedition of this year: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. D. W. Lockwood, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; Second Lieut. D. A. Lyle, Second Artillery, U. S. Army, assistant executive officer and field astronomer; A. H. Cochrane, acting assistant surgeon, U. S. Army, medical officer; W. J. Hoffman, acting assistant surgeon, U. S. Army, medical officer and collector in natural history; Theodore V. Brown, hospital steward, U. S. Army, barometric observer and recorder; Frank Hecox, hospital steward, U. S. Army, barometric observer and recorder; E. P. Austin, astronomical observer and computer; Archibald R. Marvine, astronomical observer and assistant geological observer; P. W. Hamel, Louis Nell, Joseph R. Mauran, Frank R. Simonton, and Charles E. Fellerer, geodetic and topographic assistants; Francis Klett, assistant topographer and clerk; William J. Bradley, barometric recorder; Charles A. Ogden, barometric observer and recorder; Frederick W. Loring, barometric observer and recorder; John Smith, barometer and odometer observer and recorder; G. K. Gilbert, geological observer; F. Bischoff, zoological collector; John Kohler, zoological collector; T. H. O'Sullivan, photographer; E. M. Richardson, general assistant; W. D. Wheeler, clerk; E. Martin Smith, Charles King, Charles Spencer, Willard Rice, William Egan, and Charles Hahn, guides.

The permanent escort was composed of six non-commissioned officers and twenty-six privates, Company I, Third Cavalry. Additional temporary escorts were obtained from several of the posts in Arizona, also the requisite number of cargadores, packers, teamsters, mechanics, laborers, etc.

The transportation was in the main by pack-train, wagons in certain instances conveying supplies to rendezvous points.

The following were members of the boat parties engaged in exploration of the Colorado River, including a part of the "Grand Cañon" from Camp Mohave to mouth of Diamond Creek: (1) Lieut. George M. Wheeler; (2) Dr. W. J. Hoffman; (3) P. W. Hamel; (4) G. K. Gilbert; (5) Frank Hecox; (6) T. H. O'Sullivan; (7) Frederick W. Loring; (8) E. M. Richardson; together with six boatmen and mechanics, two enlisted men of expedition escort, one sergeant and five privates from Company G, Twelfth Infantry; also Captain Asquit and thirteen other Mohave Indians, to assist in towing and general work.

INSTRUMENTS.

The following instruments were used:

Astronomic.—At the main stations a combined meridian instrument, sextants with artificial horizons, and chronometers.

Topographic.—Six-inch theodolites, reading by vernier to 20″+30″ in arc; 3-inch transit theodolites, gradienters, and pivot-levels (Wurdemann pattern), field, prismatic, and pocket compasses, steel and linen tapes, and odometers attached to vehicles. For the inclination of the magnetic needle a dip circle was employed. For hypsometric purposes, cistern, mountain, and aneroid barometers, hygrometers, maximum and minimum and pocket thermometers were used.

The instruments of the geologists were pick and hammer, clinometer compasses, aneroid barometers, and hand levels.

REPORTS.

A special preliminary report of this exploration and survey was made to Brig. Gen. A. A. Humphreys, Chief of Engineers, U. S. Army, early in 1872, and published by departmental authority. A preliminary topographic map on a scale of 1 inch to 24 miles accompanied the report, embracing a skeleton of the general topographic information collected, location of routes pursued, positions of mining camps, etc.

A few copies, expressly for office use, of a list of camps, distances, etc., of the expedition of this year, were printed in oblong folio.

On account of the urgency of other duties no regular annual report for the fiscal year 1870–'71 was submitted to the Chief of Engineers.

At the close of this expedition a plan for a systematic topographic survey of the territory of the United States west of the 100th meridian was, by request, prepared by Lieutenant Wheeler, approved by the Chief of Engineers and the honorable the Secretary of War, and sanctioned by act of Congress approved June 10, 1872.

To facilitate operations, initial main astronomic stations were established this season (longitude by telegraph) at the following points: Carlin, Battle Mountain, and Austin, Nev.; Camp Independence, Cal.; St. George, Utah; and Prescott, Ariz. Including the points determined in 1869, eleven main astronomic stations were established by the survey in the western interior, and the longitude of nine established by telegraph.

The majority of these stations was confined to the main lines of the survey. Minor astronomical stations were established daily along the routes, the prominent mountain peaks were occupied as subordinate triangulation stations, while the extent of the country to be traversed precluded the possibility of carrying out any connected net-work of triangulation.

The principal mountain passes were traversed and profiled, and topographic sketches made at both prominent and minor points. Elevations were obtained of most of the prominent features of the country, and tri-daily meteorological observations made constantly by all the different parties.

The portion of the area surveyed during this season, with the most topographic detail, was that embracing the Colorado River, and that receiving most attention in a physio-geographical view, was the Great American Desert region, which was found to vary in breadth from 75 to 250 miles. The Grand Cañon of the Colorado was explored in boats, occupying one branch of the survey, under the immediate command of Lieutenant Wheeler, thirty-three days in the ascent of the river from Camp Mohave to Diamond Creek, a distance of more than 200 miles. More than two hundred rapids were passed during the trip, and there was revealed the most striking cañon scenery in the world, of some of which photographic pictures were made. The trip was one of great hardship, and notwithstanding the loss of some of the instruments, which limited observations, and a part of the records, was highly successful.

In addition to the highly interesting exploration of the Colorado Cañon the extent and character of the great Colorado Plateau, first defined and named by myself, were determined, and its peculiar features delineated.

The expedition also determined the existence and limits of several inclosed basins without outward drainage, and separate from the Great Salt Lake and Humboldt basins. These are mostly in Nevada, the Amargosa or Death Valley Basin, being most extensive and characteristic, its lowest depression being below the level of the sea.

Ninety-two mining districts were embraced in the area surveyed, eighty-six of which were visited by one or more of the members of parties, and much information elicited in classified form. Notes of the principal features of the mines appear in the report. The mapping of mineral districts, showing their positions, direction of lodes, etc., was made a part of the work of the survey.

A full series of meteorologic observations was taken during the season. The geological information acquired enabled a plan to be projected of a final comprehensive report. The natural history collections, except of coleoptera and in botany, were small, owing to the desolate nature of the regions visited and rapid movements of the parties. Mineralogical specimens were collected mostly from the mining regions.

Observations were made with a view to the practicability of establishing north and south lines of communication, and one from Salt Lake southerly to the foot of the Grand Cañon of the Colorado; one from the Central Pacific Railroad through Washoe, east of the Sierras; and one from a central point on the Central Pacific across the Colorado River at the mouth of Virgin River, were recommended as practicable.

The navigability of the Colorado River to Camp Mohave was noted, and the practicability of navigation to Callville, a point 95 miles above Camp Mohave, has been proved in an instance mentioned; and it is concluded that steam navigation may ultimately be carried to the foot of the Grand Cañon, 57 miles above Callville, or 577 miles above the mouth of the river.

The areas inhabited by the Shoshones, Pah-Utes, Chemehuevis, Utes, Mohaves, Seviches, Hualapias, Apache-Mohaves, Cosninas, and Apaches, were accurately determined and mapped, and information respecting the numbers, manner of life, and disposition of these Indians towards the whites, collected. Three members of the expedition were murdered near Wickenberg, Ariz., by Indians, near the end of the season, while en route home. Remnants of the works of extinct aboriginals were met with during the exploration.

The expedition reached Tuscon, Ariz., for disbandment December 4, 1871, after a protracted field season of a little more than seven months. A temporary office for both business and reduction purposes was occupied for a brief period in San Francisco, the balance of the winter months being spent in Washington, D. C., in the preparation and publication of results.

EXPEDITION FOR EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN UTAH, NEVADA, AND ARIZONA, IN 1872.

The survey of 1872 commenced July 7, and was completed on the 11th of December.

The chief objects were to establish main astronomic stations, in pursuance of a comprehensive system, at points available by telegraph and contiguous to the areas of survey, in addition, to obtain the topographic details of the sections visited, with sufficient accuracy to enable routes of communication necessary for military operations to be delineated, as well as to enable the general physical features of the country to be drawn to a scale of 1 inch to 8 miles, this projection having been determined upon for the atlas intended to cover that portion of the territory of the United States lying west of the 100th meridian.

As the survey progressed data were gathered for maps of the scale of 1 inch to 4 miles, 1 inch to 2 miles, 1 inch to 1 mile, and 1 inch to 1,500 feet, the latter at prominent mining districts.

Meteorologic observations were made hourly at the main astronomic stations, and such geologic and mineralogic examinations as could be prosecuted were made to determine the physical structure, with its geographic and allied characteristics, and incidentally an examination of the condition of the mining industry in the region visited.

Collections in the remaining branches of natural history were also made. Photographs representing geologic formations and other peculiar natural features were taken. Such general data bearing upon the subjects of irrigation, agriculture, sites for military posts, etc., as could be had were also obtained.

Observations upon the varied native resources of the soil and underlying rock, in accordance with formal instructions, were undertaken for the first time.

The main astronomical stations occupied were at (1) Beaver, Utah; (2) Cheyenne, (3) Fort Fred. Steele, and (4) Laramie, Wyo.; (5) Pioche, Nev.; (6) Gunnison, Utah, and (7) Green River, Wyo., independent of the secondary and daily latitude stations.

Reports upon results at these stations will be found in (1) Preliminary Report for 1872, (2) Special Astronomic Report, 1874, and (3) Vol. II, Quarto Reports.

The area embraced was 47,366 square miles, including portions of central, western, and southwestern Utah, eastern Nevada, and northwestern Arizona.

The areas of the expeditions of 1869 and 1871 were entered along certain lines.

The following constituted the personnel of the year: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. R. L. Hoxie, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. W. L. Marshall, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; Second Lieut. W. A. Dinwiddie, Second U. S. Cavalry, commanding cavalry escort; Second Lieut. Wallace Mott, Eighth U. S. Infantry, commanding infantry escort; H. C. Yarrow, acting assistant surgeon, U. S. Army, medical officer and zoological observer; Theodore V. Brown, hospital steward, U. S. Army, barometric observer and recorder; E. P. Austin, John H. Clark, William W. Marryatt, astronomic observers and computers; Louis Nell, John E. Weyss, Gilbert Thompson, Frank R. Simonton, and Henry Cruger, geodetic and topographic assistants; Francis Klett, assistant topographer and clerk; William M. Ord, assistant surveyor and recorder; William Kilp, C D. Gedney, Mark S. Severance, barometric observers and recorders; G. K. Gilbert, geological observer; Edwin E. Howell, assistant geological observer; H. W. Henshaw, ornithologist and collector; William Bell, photographer; George W. Bean and ——— Adams, guides.

The escort consisted of one sergeant, two corporals, and twenty privates from Company D, Second Cavalry, under the command of Second Lieut. William A. Dinwiddie, Second Cavalry, and three non-commissioned officers and thirty privates from Companies B, C, D, E, F, H, and I, Thirteenth Infantry, under the command of Second Lieut. Wallace Mott, Eighth Infantry.

The requisite number of chief packers, cargadores, packers, herders, teamsters, laborers, etc., were also a part of the expedition.

Instruments.—The astronomical instruments used were the same as those of 1871, with the addition of cylinder chronographs (Harkness pattern), for recording observations and signals, and break-circuit chronometers.

Signals for time comparisons were sent from the main and secondary stations in the field to the observatory in Temple Square, Salt Lake City.

With the addition only of compensated steel tapes, the topographic instruments used were the same as those employed in 1871, and the meteorologic instruments were identical with those employed during the previous year. The geologist used the same implements as those of 1871, while the photographer introduced the dry-plate process with success.

Reports.—A special report in quarto of this expedition was made to the office of the Chief of Engineers and printed by departmental authority. The report was accompanied by a skeleton map of the region west of the 100th meridian, on a scale of 1 to 6,000,000, illustrative of a scheme for mapping the entire area on a scale of 1 inch to 8 miles.

An annual report of operations for the fiscal year 1871–'72 was submitted to the Chief of Engineers, and appears as Appendix DD to his report for that year. (See also p. 101, Annual Report Chief of Engineers, 1872.)

A table of camps, distances, altitudes, etc., was published for office use, being a preliminary rather than completed work, and will contribute its quota to the geographic positions, distances, azimuths, altitudes, etc., to be specially prepared. (See Appendix LL, Annual Report Chief of Engineers for 1875.)

Besides the labor bestowed upon the principal objects of the survey this year, as above indicated, considerable attention was given to the subject of irrigation in connection with observations upon the agricultural resources of the country traversed.

Twenty-five mining districts in Utah, twelve in Nevada, and eleven in Arizona, forty-eight in all, were examined this season, and most of them described in the annual report to the Chief of Engineers.

A route of proposed communication from the head of the Sevier Valley, Utah, to Prescott, Ariz., was examined this year and found practicable even for a railroad, the point offering the most severe profile being that of descent into the basin of the Virgin River. The distance by the shortest of these routes from Salt Lake to Prescott is 585 miles. Other routes from Salt Lake south were partially examined during the season. The establishment of a military camp not far from St George upon the route most fully examined was suggested.

Two parties visited special points of the lower Grand Cañon of the Colorado. Some striking topographic details were gathered and photographic pictures taken.

Over one hundred and ninety species of birds were represented in the collections this year, and the specimens of reptiles and fishes numbered over four hundred. A description of them is contained in Vol. V of the regular series of quarto reports.

The area covered by the survey at the close of 1872 was a little over 155,000 square miles, an area as large as New England and the Middle States; and 6,137 miles were traversed beside the routes of the supply parties—2,067 miles in length. The large amount of geographic and topographic information collected is presented in the regular atlas sheets.

EXPEDITION FOR GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS IN COLORADO, NEW MEXICO, UTAH, AND ARIZONA, IN 1873.

The expedition took the field in three divisions, organized, respectively, at Santa Fe, N. Mex.; Salt Lake City, Utah, and Denver, Colo. The first, under immediate command of Lieut. G. M. Wheeler, left the rendezvous camp early in June; the second, under Lieutenant Hoxie, on May 30; and the third, under Lieutenant Marshall, about June 1, 1873.

The object of the survey was to gather data for topographic and geologic maps of the area explored, in accordance with the systematic plan submitted the year previous, and to gather information in the various branches of natural history. The data necessary to an approximate land classification, such as arable and irrigable, timber, grazing, etc., was gathered incidentally to the main objects of the survey more in detail than for the previous year.

The routes traversed were numerous and such as would lead the various parties from point to point in the fields of their labors in the political divisions named in the title hereof.

The area embraced was 72,500 square miles, including portions of central and southern Utah; northern, central, eastern, and southeastern Arizona; southwestern, western, northwestern, and central New Mexico; and central, southern, and southwestern Colorado. The area of the expedition of 1872 was entered along certain lines.

The personnel of the expedition was as follows: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. R. L. Hoxie, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. W. L. Marshall, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Samuel E. Tillman, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; Second Lieut. A. H. Russell, Third U. S. Cavalry, assistant executive officer; Second Lieut. L. H. Walker, Fifteenth U. S. Infantry, commanding escort; J. T. Rothrock, acting assistant surgeon, U. S. Army, medical officer and botanical observer; C. G. Newberry, acting assistant surgeon, U. S. Army, medical officer; Theodore V. Brown, hospital steward, U. S. Army, barometric observer and recorder; Prof. T. H. Safford, Dr F. Kampf, John H. Clark, William W.

Marryatt, and Prof. H. B. Herr, astronomic observers and computers; Louis Nell, John E. Weyss, Gilbert Thompson, E. J. Sommer, John J. Young, Max. E. Schmidt, Robert J. Ainsworth, and Edgar Schroeder, geodetic and topographic assistants; Francis Klett, assistant topographer and clerk; W. D. Wheeler, assistant surveyor and recorder; Frank M. Lee, C. D. Gedney, Bernard Gilpin, and William Looram, barometric observers and recorders; G. K. Gilbert, Prof. John J. Stevenson, and Edwin E. Howell, geological observers; Dr. Oscar Loew, mineralogic observer and chemist; H. W. Henshaw, ornithologist and collector; George M. Keasby, collector in paleontology; John Wolf, botanical collector; A. H. Wyant, artist; T. H. O'Sullivan, photographer; Charles Herman, A. A. Águirre, and John C. Lang, draughtsmen (office); George M. Lockwood, clerk (office).

The escort for the branch of the expedition leaving Santa Fe consisted at different times during the season of ten non-commissioned officers and forty-five privates of the Eighth Cavalry and Fifteenth Infantry, while Lieutenant Marshall, of the Colorado section, was escorted by three non-commissioned officers and thirteen soldiers of the Fifth Infantry, and Lieutenant Hoxie, of the the Utah section, had at his command one corporal and six privates.

Six privates were detailed from the Engineer Battalion who did service principally with the astronomic parties.

The usual number of chief packers, cargadores, packers, herders, teamsters, and laborers were also employed.

Reports.—The usual annual report for the fiscal year ending June 30, 1873, was made to the Chief of Engineers of the Army, and printed as Appendix EE of his annual report for 1873, a part being also contained in Appendix EE of the report of that office for 1874, the reports of the survey being for fiscal years ending June 30, parties of the several expeditions often being in the field at the date of the several reports.

The report for 1873 was reproduced in a pamphlet of 11 pages, being only a résumé of field operations, accompanied by a plan of publication of results of the survey, and a skeleton map on a scale of 1 to 6,000,000.

Division No. 1 of the expedition, assisted during a part of the season by Division No. 2, surveyed about 11,000 square miles in New Mexico and 17,500 in Arizona, in areas enjoying remarkable topographic features.

Division No. 2 occupied about 1,500 triangulation and topographic points, and meandered more than 1,000 miles, besides making special detours in Utah, and connected the meridian of Provo with that of the observatory at Great Salt Lake.

Six thousand square miles of difficult mountain and cañon country were mapped. This party was delayed by snow in the mountains and by the desertion of two packers with thirty mules, which were recovered after a chase of 400 miles, the delay forcing the party to subsist upon corn alone for seven days.

A party of Division No. 3 examined the mines at Central City, Black Hawk, Georgetown, Oro City, etc., and another party those at Hardscrabble and Rosita, and the Cañon City coal mines, Colorado. A main party surveyed the mountain ridges surrounding South Park, the headwaters of the Gunnison River, the drainage areas of the upper Arkansas and Gunnison and tributaries, and made numerous triangulation stations, thirty-six peaks over 13,000 feet high and many of less altitude being occupied. The area covered was nearly 21,000 square miles in extent.

The total area occupied during the field season approximated 72,500 square miles, and the number of main triangulation points occupied was eighty.

The geologic investigations determined that the Sam Pitch coal beds of Utah are of the Tertiary age; the coals of Castle Valley and southern Utah, of the Cretaceous; and that the disputed age of the coal series of Colorado is also Cretaceous.

A further study of the great lake regions of Utah was prosecuted during the season, and facts relating to the glacial period gathered. Considerable attention was given by some of the assistants to ethnologic researches with much success; and the subject of minerals, soils, etc., received attention also by competent observers.

Several regular topographic atlas sheets were completed, and certain specially interesting localities, as the San Juan mining region, in Colorado, published on larger scales.

An advance sheet issue of a portion of the topographic atlas was photolithographed during the year, and an edition of 2,000 copies printed, consisting of the following sheets, viz: Title, legend, and four atlas sheets and a drainage basin on a scale of 1 inch to 8 miles or 1 to 506,880 sheet, and a progress map, were also printed, each on a scale of 1 to 6,000,000

The latitudes and longitudes, the latter telegraphically, of the following main stations were determined by field astronomic observations of the first order of value, viz: (1) Bozeman, Mont.; (2) Virginia City, Nev.; (3) Winnemucca, Nev.; (4) Ogden, Utah; (5) Green River, Wyo.; (6) Denver, Colo; (7) Hughes, Colo.; (8) Colorado Springs, Colo.; (9) Cañon City, Colo.; (10) Trinidad, Colo.; (11) Fort Union, N. Mex.; and (12) Santa Fe, N. Mex. This vigorous campaign is duly reported in the Annual Report (1874), volume II, and special astronomical report (1874).

In addition to the advance made during the year toward placing the survey upon a geodetic basis, the preliminaries to a scheme of triangulation covering the entire region having been inaugurated, and the further development of observations looking to the approximate classification of the lands according to their agricultural and mineralogical characteristics, large advances were made in the geological examinations needed to determine the general structure of extended areas, and collections in the various branches of natural history were greatly amplified.

Although the expedition assembled at three rendezvous, the operations of the season were so conducted, by following converging lines, as to connect the areas of the branches and cement together those entered in prior years.

The area in which the heads of the Gila and its northern tributaries, the Little Colorado and Salt River, intertwine, was for the first time explored, and a reservoir lake discovered nearly in the center of this amphitheatre of 4,000 or 5,000 square miles, nestling in a frame of high and rugged ranges.

The presence of mines was noted in the Tonto Basin, below the volcanic beds, and adjacent to the crystalline rocks and the sedimentaries, although scarcely opened.

The presence of garnets, rubies, emeralds, etc., was noted north and east of old Fort Defiance, in placer ground worked from a dyke said to be persistent in a northerly direction for scores of miles. The presence of coal, noted by early explorers in the northern part of New Mexico, was corroborated at specified localities.

Parts of the southeastern extremity of the great Colorado plateau forest were traversed and their extent made known. The reservation of the Navajos and the Mescalero Apaches, together with the tracts set aside for the sixteen Pueblo tribes of New Mexico, were included in part by the examinations of the year, that embraced large areas in the Rio Grande Basin.

The explorations of the year assist in making clear routes that may practically be utilized, reaching from the valley of the Arkansas to northeastern Arizona, near Camp Apache in the Salt River Basin.

The survey parties disbanded at Santa Fe and Fort Union, N. Mex., and Denver, Colo., between December 5 and 10, 1873.

EXPEDITION FOR GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN COLORADO, NEW MEXICO, ARIZONA, AND NEBRASKA, IN 1874.

The several parties of the expedition took the field this year from the camp of organization at Pueblo, Colo., previous to and on the 6th of August.

The object was a continuation of the topographic survey of the mountain regions in the political divisions above mentioned, in pursuance of the previously established plan, and the measurement of a number of bases connected with main astronomic positions then or subsequently fixed, the development of triangulation from the plains to the mountains, making a connected system of surveys, having a sufficient number of geodetic points well determined upon which to base a mathematically constructed map. The various field parties, nine in number, were not confined to special routes, but advanced in parallel areas as nearly as the conformation of the areas of drainage would permit westward except one party, which operated on the east of the summit line of the Rocky Mountains. The territory embraced in the field of operations is bounded on the north by the latitude of the Spanish Peaks, and on the south by a latitude line passing through Santa Fe; on the east by longitude 104° 07′ 30″ west, and on the west by the western boundary of Colorado and New Mexico, approximately.

A special photographic party from this division visited the Pueblo ruins on the Chaco, and at adjacent points.

This year the work was developed into a completely connected survey resting on a geodetic base, referred to the initial geographic points constantly being established at selected points within and adjacent to the area of any given year.

A still more systematic classification of the lands was this year begun.

The area embraced was 23,281 square miles, including portions of central, southern, and southwestern Colorado, and central, northern, and northwestern New Mexico. The area of the expedition of 1873 was again entered along certain lines.

The personnel as follows: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. William L. Marshall, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Philip M Price, Corps of Engineers, U S. Army, assistant executive officer and field astronomer; First Lieut. Rogers Birnie, jr., Thirteenth Infantry, U. S. Army, assistant executive officer and field astronomer; First Lieut. Stanhope E. Blunt, Thirteenth Infantry, U. S. Army, assistant executive officer and field astronomer; Second Lieut. Charles W. Whipple, Third Artillery, U. S. Army, assistant executive officer and field astronomer; H. C. Yarrow, acting assistant surgeon, U. S. Army, medical officer and zoological observer; J. T. Rothrock, acting assistant surgeon, U. S. Army, medical officer and botanical observer; Theo. V. Brown, hospital steward, U. S. Army, barometric observer, recorder, and computer; Dr. F. Kampf and John H. Clark, astronomical observers and computers; Louis Nell, Gilbert Thompson, F. O. Maxson, Fred. A. Clarke, J. C. Spiller, Frank Carpenter, E. J. Sommer, William A Cowles, William H. Rowe, Robert J. Ainsworth, and William R Atkinson, geodetic and topographic assistants; Frank M Lee, Bernard Gilpin, B. W. Bates, Alston C Ladd, A. J. Tweed, and H. G. DuBois, barometric observers and recorders; J. B. Minnick and Irenez L. Chavez, barometric recorders; L. H. Hance, barometric recorder and collector; C. M. Morrison, barometric recorder; G. K. Gilbert, geological observer; Prof. E. D. Cope, paleontologist; Prof. C. A. White, paleontologist (office); Dr. Oscar Loew, mineralogical observer and chemist; H W. Henshaw, ornithological observer and collector; James M. Rutter, meteorological observer; Charles E. Aiken, ornithological collector; W. G. Shedd, collector; T. H. O'Sullivan, photographer; John E. Weyss, Charles Herman, and John C. Lang, draughtsmen (office); George M. Lockwook, Francis Klett, and W. D. Wheeler, clerks; Almont Barnes, general assistant.

The expedition of 1874 was unaccompanied by an escort. The requisite number of chief packers, cargadores, packers, herders, teamsters, and laborers were employed.

The field work of these parties completed the connection of the areas of New Mexico and Colorado, over which the surveyed portions were partially joined in 1873.

The Indians encountered this season are portions of the Ute, Apache and Navajoe tribes, and the Pueblos, none in large numbers. Except the latter, who live in villages and are agricultural and pastoral, they were not inclined to be specially friendly.

The mines visited are Rosita, in the Wet Mountains, those in Los Cerillos, and the San Juan; besides a new field which was being prospected with some success on the Alamosa.

One of the important discoveries this season was that of a new pass through the main divide of the Rocky Mountains, near the head of the main fork of Poncha Creek, just south of Hunt's Peak. It is lower than any pass across these mountains in Colorado, and will admit of a grade of not more than 212 feet to the mile for a road from Pueblo or Cañon City, on the Arkansas. By this pass 80 miles in distance can be saved to the Gunnison River and mines at its head. This pass (since used by the Denver and Rio Grande Railroad) has been named from its discover, Lieutenant Marshall.

The discoveries and collections in natural history were also important, and in several fields include new varieties and species. In the vicinity of San Ildefonso the discoveries embrace specimens of fish, of which quite a number of *Cyprenidæ* are new. Human remains of a tribe of which we have no history were found at a ruined fortified town at Abiquiu. In botany 9,000 specimens were collected. In ornithology, besides many varieties, six species were added to the known fauna of the United States.

An extensive series of deposits of the Eocene age was discovered in New Mexico, and its examination rewarded by the collection of remains of a considerable number of species of vertebrata, mostly mammalia, and among them four species of two new genera of *Toxodonita*, an order not previously identified as having existed on this continent. Many mineral springs were visited by the different parties; and vocabularies were made of four Indian languages.

The following is a summary of the field and office work during the year, viz:

Field.—Main telegraphic longitude stations, 5; latitudes determined, main stations 6, sextant stations 50; main triangulation stations occupied, 51; topographical stations occupied, 103; miles traveled, 11,440; main barometric stations occupied, 572; aneroid stations, 3,335; botanical specimens collected, 9,000; specimens of mammals, fish, reptiles, and insects, 20,155; specimens of birds, 1,227; other ornithologic specimens, 83; lots of geologic and mineralogic specimens, 497.

Office.—Astronomic positions computed, 55; sheets plotted, 15; cistern barometer altitudes computed, 872; aneroid barometer altitudes computed, 3,965. Atlas maps, 1 inch to 8 miles, published, 8; ready for publication, 3; partly completed, 2. Atlas sheets, 1 inch to 8 miles and 1 inch to 4 miles, in preparation, 13. Reports published, 5; in course of publication, 2; nearly ready for publication, 4. Maps distributed, 7,864.

Results obtained during the year of observations at Julesburg, which location was placed on some of the Government maps north of latitude 41° in Nebraska, show that it lies south of that latitude in Colorado. The astronomic co-ordinates of the main stations at Las Vegas and Cimmaron, N. Mex., Sidney Barracks and North Platte, Nebr., and Julesburg, Colo., were determined.

The astronomic instruments employed were similar to those of the preceding year with the addition of an automatic instrument for the determination of positive personal equation.

The additional implements of the geologists were picks and heavy chisels for collecting vertebrate fossils.

No special report of this survey was made except that which is contained in the regular annual report submitted by the officer in charge to the

Chief of Engineers, June 30, 1875, which is printed as Appendix LL to the Report of the Chief of Engineers for that year.

During this year's operations of the survey a number of topographic and geographic maps of the regular series were prepared and published.

EXPEDITION FOR GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN COLORADO, NEW MEXICO, NEBRASKA, UTAH, CALIFORNIA, AND NEVADA, IN 1875.

The expedition was organized in two sections of three parties each, one to operate from Los Angeles, Cal., and the other from Pueblo, Colo., at initial points. The California division disbanded at Caliente, Cal., in November, 1875, and the Colorado section at West Las Animas, Colo., November 25.

The object of the survey, as in preceding years, was primarily the collection of data for the construction of detailed topographic maps, in pursuance of the systematic geographic and topographic survey of the western mountain region.

In addition, and to the extent practicable, investigations were conducted in geology, paleontology, mineralogy, and the several branches of zoology and botany. All mines and mining camps that could be reached were visited and examined, and mineral and thermal springs noted.

The systematic classification of the land hitherto begun received especial attention during this and subsequent seasons, becoming one of the most important incidentals to the main objects of the survey.

Careful and copious notes taken by the topographers of the several parties enable the areas entered to be divided into arable, grazing, timber, and desert, and also with reference to the presence of the precious and economic minerals at a trifling additional labor and expense.

The topographic maps serve as a basis for the delineation of these subdivisions in colors.

The area occupied was 39,169 square miles, including portions of southern Colorado, northern New Mexico, southern California, small sections in southwestern Nevada, and western Arizona.

The areas occupied during seasons of 1869–'71, 1873, and 1874 were again entered along certain lines with a view to perfect the triangulation and other connections of the areas of former years.

The personnel of this expedition was as follows: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. William L. Marshall, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Eric Bergland, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. William L. Carpenter, Ninth Infantry, U. S. Army, assistant executive officer; First Lieut. Rogers Birnie, jr., Thirteenth Infantry, U. S. Army, assistant executive officer and field astronomer; First Lieut. Charles C. Morrison, Sixth Cavalry, U. S. Army, assistant executive officer and field astronomer; Second Lieut. Charles W. Whipple, Third Artillery, U. S Army, assistant executive officer and field astronomer; H. C. Yarrow, acting assistant surgeon, U. S. Army, medical officer and zoological observer; J. T. Rothrock, acting assistant surgeon, U. S Army, medical officer and botanical observer; Theodore V. Brown, hospital steward, U. S. Army, barometric computer; Dr. F. Kampf, triangulation observer and computer; Louis Nell, Gilbert Thompson, F. O. Maxson, J. C. Spiller, Frederick A. Clark, Frank Carpenter, William A. Cowles, Anton Karl, and George H. Birnie, geodetic and topographic assistants; Frank M. Lee, William Sommers, William C. Niblack, George M. Dunn, John A. Hasson, Alston C. Ladd, and William Looram, barometric observers and recorders; Frank Holland and T. Von Brockdorff, barometric recorders; Prof. Jules Marcou, geological observer; Dr. Oscar Loew, geologic and mineralogic observer and chemist; Alfred R. Conkling, geological observer; Douglas A. Joy, geological assistant; H. W. Henshaw, zoological observer and collector; Charles F. Shoemaker, collector; Francis Klett and W. D. Wheeler, clerks (field); William H. Rideing, general assistant; John E. Weyss, Charles Herman, and John C. Lang, draughtsmen (office); Prof. F. W. Putnam, ethnologist (office); George M. Lockwood and J. D. McChesney, clerks (office).

The expedition was accompanied by two engineer soldiers and one sergeant and nine privates of the Twelfth Infantry; also the usual number of chief packers, cargadores, packers, herders, teamsters, laborers, etc.

Some of the work finished this year has permitted the completion and publication of maps of all those mountainous portions of the West of most intricate drainage areas, upon a scale of 1 inch to 4 miles, besides furnishing material for other maps, complete or in progress, on a scale of 1 inch to 8 miles, for the plateau and semi-desert regions.

Lieutenant Marshall, in charge of party No. 1, Colorado section, surveyed an area in south central Colorado, or that portion of the Platte and Arkansas divide between the southern edge of South Park and the Arkansas River.

The following is a general summary of important results of the season's work:

Sextant latitude stations	108
Bases measured	105
Triangles about bases measured	50
Main triangulation stations occupied	111
Secondary triangulation stations occupied	273
Three point stations occupied	436
Camps made	695
Miles meandered	9,463.3
Miles traversed not meandered	4,799.9
Stations on meanders	885
Magnetic variations observed	228
Monuments built	237
Cistern barometer stations occupied	707
Aneroid stations occupied	5,553
Mining camps visited	29
Mineral and thermal springs noted	21
Geological and mineralogical specimens collected	389
Paleontological specimens collected	107
Botanical specimens (species) collected	350
Mammals, specimens collected	90
Birds, specimens collected	710
Other ornithological specimens collected	57
Reptiles, lots collected	67
Fishes, lots collected	29
Insects, lots collected	385
Shells, lots collected	19
Crustacea, lots collected	11
Radiates, lots collected	5
Ethnological specimens collected	363

The only noteworthy change made this year in the instruments used by the survey was in the transit. An instrument subsequently known as "Young's Meander Transit" was devised from notes furnished by the topographers of the survey as the result of experience required, and has been adopted as combining in as great a degree as possible, strength, simplicity of design, and convenient size, with the necessary accuracy of results.

The pack-train of mules represented the only means of transportation for the working parties.

A report of the season's operations was made as Appendix J J of the Annual Report of the Chief of Engineers for 1876. This was subsequently repaged and published as Annual Report upon the Geographical Surveys West of the one-hundredth meredian.

This annual report contains, in addition to the executive and descriptive reports of the officers in charge of parties, a number of professional papers.

During the year two large quarto volumes (III and V) were issued from this office.

The archeological investigations about Santa Barbara resulted in the acquisition of a large amount of very valuable material in the shape of Indian utensils, implements, etc., which were exhumed under circumstances that proved, for some of them at least, a considerable antiquity.

Dr. Loew conducted a series of interesting experiments with reference to the determination of the physiological effects upon the human system of the hot climate of the Colorado Valley, where the temperature of the air rises above blood-heat for weeks in summer.

Upon studying the Indian vocabularies collected by himself in the West, Dr. Loew finds that certain Pah-Ute words show a resemblance to the Chinese and Japanese languages, this similarity not being noticed in any other tribe.

The result of Lieutenant Bergland's examination of the Colorado River, with reference to the practicability of its diversion for agricultural purposes, afforded a negative answer.

Mount Whitney, or Fisherman's Peak, the highest peak in the Southern Sierras, and presumably the highest in the range, was ascended by two parties, and its height found to be 14,470 feet.

Triangulation was carried forward this season in accordance with the general plan, and the system of points connected with the work of previous years.

As a result of the work of the season in the San Juan region, a special sheet was published on a scale of 1 inch to 2 miles.

The efficiency of method of the topographic work and the accuracy in its delineation showed a notable advance in this as during each of the previous seasons.

EXPEDITION FOR GEOGRAPHICAL SURVEYS WEST OF THE ONE-HUNDREDTH MERIDIAN, IN COLORADO, NEW MEXICO, CALIFORNIA, AND NEVADA, IN 1876.

The expedition was organized in two sections; the Colorado section, of two parties, at Fort Lyon, Colo., and the California section, of four parties, at Carson City, Nev.

These sections took the field during the month of August, and were disbanded late in November at the above-named points. The delay in organization was caused by the lateness of appropriations for work of the year.

The methods and objects of the survey were the same as during the previous year. The country examined and surveyed amounted to 21,044 square miles, situated in southeastern Colorado, northern and west central New Mexico, western Nevada, and eastern California. The areas that had been visited during the years 1871, 1873, 1874, and 1875 were again entered along certain lines when necessary to perfect the continuous belts of triangulation required to cover entirely the country under examination, which latter often enters connected areas likely to be occupied in ensuing years.

The following constituted the personnel: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer and field astronomer; First Lieut. Samuel E. Tillman, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut Eric Bergland, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; Second Lieut. Thomas W. Symons, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Rogers Birnie, jr., Thirteenth U. S. Infantry, assistant executive officer and field astronomer; First Lieut. Charles C. Morrison, Sixth U. S. Cavalry, assistant executive officer and field astronomer; Second Lieut. M. M. Macomb, Fourth U. S. Artillery, assistant executive officer and field astronomer; Dr. F. Kampf, triangulation observer and computer; Louis

Nell, Gilbert Thompson, F O. Maxson, J. C. Spiller, Frank Carpenter, Anton Karl, and William A. Cowles, geodetic and topographic assistants; Frank M. Lee, Louis Seckles, George M. Dunn, William C. Niblack, Alfred Du-Bois, and S. B. Cameron, barometric observers and recorders; Isaiah Brown, messenger and barometric recorder; Alfred R. Conkling, geological observer; H. W. Henshaw, zoological observer and collector; Francis Klett, property clerk; John E. Weyss, Charles Herman, and John C. Lang, draughtsmen (office); George M Lockwood, clerk (in charge of office during field season); J. D. McChesney, money clerk (office); C. D. Davis, quartermaster's clerk (office).

Two non-commissioned officers and five privates drawn from the Twelfth and Nineteenth Regiments of Infantry accompanied the expedition, and the usual number of cargadores, packers, herders, teamsters, laborers, etc.

The geology of the mountainous area about Lake Tahoe and near Carson City was studied by Mr. A. R. Conkling in connection with party No. 2, California section, while its zoology received attention at the hands of Mr. H. W. Henshaw.

The more prominent features of the field-work for the season are indicated in the following summary:

Sextant latitude stations	74
Bases measured	2
Triangles about bases measured	60
Main triangulation stations occupied	64
Secondary triangulation stations occupied	80
Stations on meanders	5,115
Three-point stations occupied	765
Camps made	317
Miles meandered	4,379.48
Magnetic variations observed	906
Monuments built	166
Cistern barometer stations occupied	749
Aneroid stations occupied	3,804
Mining camps visited	15
Mineral and thermal springs visited	16
Mammals, specimens collected	13
Birds, specimens collected	109
Reptiles, specimens collected	10
Fishes, specimens collected	9
Insects, lots collected	31
Shells, lots collected	2

Instruments.—These were practically the same as employed previously, with such slight modifications as had been suggested by experience, especially in regard to instruments used at main triangulation stations, the object had in view being to increase the portability without decreasing the value of the instrument for accurate work.

The transportation employed was entirely that of pack-trains, except that a light spring-wagon was used by the party engaged in the valley of the Carson for the safe transit of instruments.

Pack-train transportation has been necessary in all of the expeditions, as most of the routes were over regions where no roads or trails exist.

The usual report of the season's operations was made to the Chief of Engineers, and appears as Appendix NN of that officer's Annual Report for 1877. In addition to the main report and the customary executive and descriptive reports by the officers in charge of the several parties, it contains a number of accompanying papers and several atlas sheets.

The unusual shortness of the field season had its effect in limiting the amount of work accomplished. The special survey of Lake Tahoe inaugurated this season gave satisfactory results, and the data at hand warranted the production of a map of this extremely interesting lake region on a scale of 1 inch to 1 mile.

The requirements made upon the topographers and others by which their notes furnished information relating to the natural resources of the regions traversed, especially of the amounts of arable, timber, grazing, mineral, and arid lands, very satisfactorily met, and much further valuable data was thus secured.

EXPEDITION FOR GEOGRAPHICAL SURVEYS WEST OF THE ONE-HUNDREDTH MERIDIAN IN COLORADO, NEW MEXICO, UTAH, WYOMING, IDAHO, NEVADA, CALIFORNIA, AND OREGON IN 1877.

The expedition was organized in three divisions—one, of two parties, at Fort Lyon, Colo.; a second, of two parties, at Carson, Nev.; and a third, of two parties, at Ogden, Utah.

The several parties were disbanded between the dates of November 25 and December 10, at Carson, Nev.; Ogden, Utah; Fort Garland, Colo.; and Fort Union, N. Mex.

The general plan of the survey and its objects have been detailed under accounts of previous seasons.

The field of survey comprised 32,477 square miles, in west central Colorado, central New Mexico, northwestern Utah, southeastern Idaho, northeastern and east central California, and south central Oregon.

The areas embraced by the expeditions of 1873, 1874, 1875, and 1876, were again entered along certain lines when required to complete triangulation observations and topographic details.

The personnel was as follows: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer, field astronomer, and in charge of survey; First Lieut. Eric Bergland, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Samuel E. Tillman, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; Second Lieut. Thomas W. Symons, Corps of Engineers, U. S. Army, assistant executive officer and field astronomer; First Lieut. Rogers Birnie, jr., Thirteenth Infantry, U. S. Army, assistant executive officer and field astronomer; First Lieut. Charles C. Morrison, Sixth Cavalry, U. S. Army, assistant executive officer and field astronomer; Second Lieut. M. M. Macomb, Fourth Artillery, U. S. Army, assistant executive officer and field astronomer; Dr. F. Kampf, triangulation observer and computer; Louis Nell, F. O. Maxson, Gilbert Thompson, Miles, Rock, C. J. Kintner, J. W. Ward, Alfred Downing, J. C. Spiller, William A. Cowles, Anton Karl, and E. T. Gunter, geodetic and topographic assistants; Frank M. Lee, Louis Seckels, George M. Dunn, William C. Niblack, Thomas W. Goad, John A. Hasson, Eugene L. Vail, J. M. Harris, C. D.

Davis, William Looram, F. E. McCrary, S. B. Cameron, T. H. Simpson, Jay Cooke, jr., and J. B. Callahan, barometric observers and recorders; Isaiah Brown, messenger and recorder; H. W. Henshaw, zoological observer and collector; John A. Church, mining observer; Alfred R. Conkling, geological observer; John E. Weyss, Charles Herman, and John C. Lang, draughtsmen (office); Francis Klett, clerk (field); J. D. McChesney, Gwyn A. Lyell, and C. D Davis, clerks (office).

Four privates of the Fourteenth Infantry and one of Company D, Nineteenth Infantry, accompanied the expedition, with the usual number of cooks, packers, teamsters, and men of all work.

Five main base lines were measured at (1) Ogden and (2) Terrace, Utah; (3) Verdi and (4) Austin, Nev.; and (5) Bozeman, Mont.

The triangulation observations of this season were pushed with great vigor, the nets being extended over all the territory examined and connection made with prior years.

In addition to the several main parties, the special survey of the Lake Tahoe region was completed by a party organized by Lieutenant Wheeler, and with which he remained for a short time, consisting of Mr. John E. Weyss and others.

A special party under Lieutenant Wheeler operated from Ogden to the northward to the east of Cache Valley, in vicinity of Bear Lake, along Twin Creeks, and to the eastward in the Green River drainage, disbanding at Evanston, on the Union Pacific Railroad.

The examination of the Comstock Lode, begun by Mr. J. A. Church in June, was continued during the season, his attention being exclusively directed to the structure of the vein, the regimen of the mines and the high temperature encountered in the rocks.

Mr. A. R. Conkling continued his geological investigations, taking for his field a section of eastern California and western Nevada lying between latitude 38° and 39° 30′, and longitude 119° 15′ and 120° 54′.

Collections in the several departments of zoology were made by Mr. H. W. Henshaw, in the region from Carson, Nev., along the eastern base of the Sierras, into southern Oregon; special attention being directed to the ornithology.

The following mining districts were visited during the season and reported upon: Bodie, Meadow Lake, Placerville, Washington, Castle, Alpine, West Walker, Confidence, Monitor, and Silver Mountain in California, and the Iowa district in Idaho.

The following is a brief summary of certain important features of the work:

Sextant latitude stations	145
Bases measured	6
Triangles about bases measured	56
Azimuths about bases measured	13
Main triangulation stations occupied	106
Secondary triangulation stations occupied	204
Cross-sight stations observed	1,080
Three-point stations occupied	1,414
Stations on meanders	12,366
Miles measured	10,801
Cistern barometer stations occupied	1,447
Aneroid stations occupied	8,900
Magnetic variations observed	454
Rivers and creeks gauged	56
Camps made	761
Monuments built	367
Mining camps visited	19
Mineral and thermal springs noted	60
Minerals, fossils, and ores (specimens of) approximate	1,100
Mammals, specimens collected	14
Birds, specimens collected	228
Reptiles, lots collected	11
Fishes collected, lots	23
Fishes collected, specimens	200
Insects, lots collected	14
Shells, lots collected	8

No changes were made in the class of instruments used.

Reports, more or less in detail, of the routes followed by the several parties, and descriptive accounts of the areas examined, appear as Appendix NN in the Annual Report of the Chief of Engineers for 1878, accompanied by special reports and a number of atlas sheets.

This Appendix was repaged and printed separately as Annual Report upon the Geographical Surveys of the Territory of the United States West of the One-hundredth Meridian.

Volumes 2 and 4 of the quarto series were issued during the year.

The season of 1877 included a period of from six to seven months, and was an extremely successful one in almost all the several branches of the work, resulting in a very large accumulation of data.

Among other interesting matters may be mentioned the tracing of the Bonneville Beach, or outlines of the ancient fresh-water lake of the Great Basin, northward through Cache Valley and westward through Malade Valley. Sufficient additional information was obtained regarding this ancient lake to complete its outlines.

The collection of fishes of this season, though small, proved to be extremely interesting; besides containing two new species it illustrated several items of importance respecting the geographic range of previously known species.

EXPEDITION FOR GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN, IN COLORADO, NEW MEXICO, UTAH, CALIFORNIA, NEVADA, OREGON, AND WASHINGTON, IN 1878.

The expedition took the field in three divisions of three parties each. Of the Colorado division one party was organized at Fort Stanton, N. Mex., and two at Fort Garland, Colo. The two parties of the California division were organized respectively at Carson, Nev., and at Camp Bidwell, Cal., Ogden, Utah, was the initial point of the Utah section.

Owing to the lateness of the appropriation field work was not begun until the 1st of July.

The parties were disbanded after a season of about five months.

An area aggregating 25,550 square miles was occupied, situated chiefly in southwestern New Mexico, northern Utah, northern, central and southwestern California, western Nevada, and central Oregon.

Areas embraced during the seasons of 1873, 1874, 1875, 1876, and 1877 were again visited along certain lines when rendered necessary in perfecting triangulation and topographic details.

The following were the personnel: First Lieut. George M. Wheeler, Corps of Engineers, U. S. Army, in command, chief executive officer, field astronomer and in charge of survey; First Lieut. Samuel E. Tillman, Corps of Engineers, U. S. Army, assistant executive officer, field astronomer and triangulator; First Lieut. Thomas W. Symons, Corps of Engineers, U. S. Army, assistant executive officer, field astronomer and triangulator; Second Lieut. Willard Young, Corps of Engineers, U. S. Army, assistant executive officer, field astronomer and triangulator; Second Lieut. Eugene Griffin, Corps of Engineers, U. S. Army, assistant executive officer, field astronomer and triangulator; First Lieut. Rogers Birnie, jr., Ordnance Corps, U. S. Army, assistant executive officer, field astronomer and triangulator; Second Lieut. M. M. Macomb, Fourth U. S. Artillery, assistant executive officer, field astronomer and triangulator; Second Lieut. Henry H. Ludlow, Third U. S. Artillery, assistant executive officer and triangulation observer; Second Lieut. B. H. Randolph, Third U. S. Artillery, acting assistant quartermaster, acting assistant commissary of subsistence, and ordnance officer; Prof. T. H. Safford and Miles Rock, astronomic observers and computers; John H. Clark, astronomic observer; Louis Nell, Gilbert Thompson, F. O. Maxson, J. C. Spiller, Frank Carpenter, Anton Karl, James S. Polhemus, Charles P. Kahler, W. G. Walbridge, and Ed. Gillette, jr., geodetic and topographic assistants; Francis Klett, assistant topographer and clerk; Thomas W. Goad, George M. Dunn, Frederick W. Floyd, G. H. Schleicher, John A. Hasson, Louis Seckles, H. S. Wallace, William Hollis, John H. Morgan, Mark B. Kerr, and William L. Bailey, barometric observers and recorders; Sergt. Thomas Knight, Company F, Fourteenth Infantry, barometric observer; Isaiah Brown, barometric observer and messenger; R. Pitcher, Edward W. Lyon, John Bishop, W. A. Purington, W. A. Phillips, jr., and J. B. Callahan, odometer observers and recorders; Prof. J. J. Stevenson, geological observer; Israel C. Russel, assistant geological observer; H. W. Henshaw, zoological assistant; Almont Barnes, general assistant and clerk; C. S. Chesney and C. D. Davis, clerks (office and field).

Office.—First Lieut. Charles C. Morrison, Sixth U. S. Cavalry, temporarily in charge; John D. McChesney, money clerk; John C Lang, Charles Herman, and John E. Weyss, draughtsmen; Gwynn A. Lyell, draughtsman and clerk; Alfred Downing, draughtsman and computer; James M. Ewing, clerk.

The Army furnished one sergeant, one corporal, and two privates of the Fourteenth Infantry, and the usual quota of packers, laborers, etc., were hired.

In addition to the regular organizations covering contiguous and connected areas, the following special parties were sent out during this season:

A party in charge of Lieutenant Young was intrusted with the survey of Great Salt Lake. This included a meander of its shore line and of the islands, the gauging the amount of inflowing water, the determination of the amount of surface evaporation, and the rise and fall of the lake, as well as the topography of the country immediately bordering the lake and the islands. The Terrace-Lucin base-line previously measured was leveled and connected with the general triangulation system.

The detailed plane table contour survey of the Washoe mining region was completed and copies of the maps of all the underground workings kept up. Lieutenant Young visited several mining districts in southern California; Lieutenant Birnie others in New Mexico. (See Annual Report, 1879.)

Initial astronomical stations (with telegraphic determination of longitude) were concluded at (1) Fort Walla Walla, Wash.; (2) The Dalles, Oregon; (3) Fresno, Cal.; (4) Fort Bayard, N. Mex., and (5) Fort Bliss, near El Paso, Tex. Signals were sent from Fort Bayard Station to Ogden, Utah, by both an eastern and western circuit, thus affording independent determinations for comparison. Bases were measured at each of these points and developed connecting with the triangulation in every instance except at Walla Walla. An auxiliary basis was also measured near Austin, Nev.

The base line of 24 miles measured between Lucin and Terrace, Utah, was developed to connect with the triangulation work, the latter being carried, as was the custom, over the entire area surveyed in 1878 and where practicable extending it across to points lying in areas of prior years.

Prof. J. J. Stevenson continued his examination of the geology of certain areas in south central Colorado and north central New Mexico, which includes parts of the three great drainage areas—those of the Purgatory, the Canadian, and the Rio Grande.

Mr. H. W. Henshaw accompanied party No. 1, California section, and made zoological collections in the region traversed, with a special view to the study of its ornithology.

Fourteen mining districts were reported upon, viz: Ridge Bar, San Gabriel, San Antonio, Holcomb, Bear Valley, and Lone Valley, California; the Lone, Chloride, Mimbres, Pinos Altos, Aztec and Moreno, Los Cerillos, and Placer Districts, New Mexico; and the Las Animas District, Colorado.

The following table expresses certain of the prominent features of the field work:

Number of main astronomical stations	5
Sextant latitude stations	90
Bases measured	5
Triangles about bases measured	64
Main triangulation stations occupied	70
Secondary triangulation stations occupied	67
Three-point stations occupied	763
Stations on meander	15,996
Miles measured	10,299
Cistern barometer stations occupied	1,041
Aneroid stations occupied	7,057
Magnetic variations observed	197
Monuments built	150
Mining camps visited	15
Mineral and thermal springs noted	22
Minerals, fossils, and ores collected (approximate)	1,467
Mammals, specimens collected	11
Birds, specimens collected	943
Birds' eggs collected	13
Mammals (alcoholic) collected	3
Mammal crania collected	1
Bird crania collected	7
Fishes, specimens	800
Fishes, lots	19
Snakes, specimens	55
Snakes, lots	16
Lizards, specimens	25
Lizards, lots	7
Batrachians, specimens	60
Batrachians, lots	11
Hemiptera collected	1
Orthoptera, specimens	200
Orthoptera, lots	6
Shells, specimens	55
Shells, lots	3
Crustaceans, specimens	12
Crustaceans, lots	1
Fossil leaves, specimens	79

The field instruments employed were those given in description of "methods."

A report of the season's results appeared as Appendix OO of the Chief of Engineers Annual Report of 1879. A repaged edition was issued as the annual report of the survey, Vol. VI, Botany, of the quarto series issued from the press during the year.

With the report was a progress map and an outline map of the Comstock Lode. Accompanying the report, but in separate covers, were seven quarter atlas sheets.

The results of the season of 1878, while presenting no especially novel features as contrasted with previous years, are yet notable in a general way for the great amount of work accomplished and the value of the data gathered bearing on the several subjects of inquiry. In this respect this, the latest field season, exceeds in the aggregate of its results any previous year. While this gratifying showing is in part due to the large working force employed, no small amount of the credit should be attributed to the improved methods of work, and to the experience in their several departments gained by the members of the survey. Experience in extended surveys is especially necessary. In fact nowhere is the value of a skilled personnel more apparent than in a survey of the far West, where new problems and unforeseen contingencies are continually arising that tax ingenuity, patience, and forethought to their utmost.

GEOGRAPHICAL SURVEY PARTIES FOR THE SEASON OF 1879, IN COLORADO, CALIFORNIA, AND UTAH.

No funds for *field* operations being available after June 30, comparatively little work was accomplished during the field season of 1879. Several small parties were, however, sent out to complete details in certain areas entered during the years 1873, 1875, 1877, and 1878.

A party under Lieutenant Young continued the hydrographic and topographic survey of Great Salt Lake, occupying the interval between April 22 and June 30.

A second party, with Lieutenant Macomb as executive officer, took up the survey of the area in east central California, as left by his division at the close of the field season of 1878, and finished important details. This party was in the field from May 16 to June 27.

A party under Louis Nell was engaged in triangulation observations in central Colorado; it localized a number of new mining camps, as Silver Cliff, Leadville, Ten Mile, Carbonate, Frying Pan Gulch, Monarch, and the new discoveries in the basin of the Gunnison.

Professor Stevenson again entered, for a brief interval, the scene of his previous year's labors, and filled in certain gaps in the work. He also visited and examined the mines of the Placer Mountains and of Los Cerillos near Galisteo Creek.

Reports by Lieutenants Young and Macomb on the work intrusted to them, and a preliminary report by Professor Stevenson on the section examined by him, will be found in the annual report for 1879, as cited above.

The personnel was as follows: Capt. George M. Wheeler, Corps of Engineers, U. S. Army, in command; First Lieut. B. H. Randolph, Third Artillery, U. S. Army, field quartermaster, ordnance officer, and commissary; Second Lieut. Willard Young, Corps of Engineers, U S. Army, chief of party and field astronomer; First Lieut. M M. Macomb, Fourth Artillery, U. S. Army, chief of party and field astronomer; Louis Nell, chief of party, triangulation and topographic observer; F. O. Maxson, field triangulation and topographic observer; Prof. John J. Stevenson, chief of party and geological observer; Francis Klett, topographer and surveyor; E. Gillette, jr., assistant topographer; Louis Seckles, barometric observer and recorder; C. D. Davis, clerk; Isaiah Brown, barometric recorder and messenger; Sergt. Thomas Knight, Company F, Fourteenth Infantry, U. S. Army, barometric observer and recorder; Corp. Joseph T. Hill, Company I, Fourteenth Infantry, U. S. Army, odometer recorder.

Office, July 1, 1879.—First Lieut. Samuel E. Tillman, Corps of Engineers, U. S. Army, temporarily in charge; John D. McChesney, money clerk; H. W. Henshaw, clerk in charge of reports and publications; Miles Rock, astronomic and geodetic computer; Fred. W. Floyd, computer; Charles P. Kahler, J. S Polhemus, J. C. Spiller, Gilbert Thompson, and Anton Karl, topographic assistants; Charles Herman, John C. Lang, John E. Weyss, and Albert Noerr, draughtsmen; James M. Ewing and Mark B. Kerr, clerks; John W. Irwin, jr., general assistant.

Subsequent to July 1, with all available means and assistants, the various reports and maps were brought as near as possible to completion (see list of reports and maps in this volume), while finally the office closed for lack of funds, February 28, 1884; since which, as circumstances have permitted, the volume on geographic positions, etc., the Venice report, and the present and final volume have been issued, as also a number of maps.

The mountainous part of the total area of 1,443,360 square miles west of the one-hundredth meridian is 993,360 square miles, of which 359,065 square miles were surveyed topographically and otherwise examined during the expeditions above noticed. A summary of results in the several branches appears on pages 137 to 146 of the volume herewith. The manner of conducting the survey operations (observations and reductions) will be found as Appendix C of this volume.*

Of necessity much material and many records, incompletely reduced, were transferred to the Engineer Department, U. S. Army, as were all original field and manuscript records of the astronomic, geodetic, trigonometric, topographic, hypsometric, and magnetic departments, including original triangulation sheets (unpublished); original platting sheets (published); original platting sheets (unpublished), and original finished topographic sheets (published).

Nothing was elsewhere or otherwise transferred. Numerical results for latitudes, longitudes, and altitudes will be found distributed through the annual, special, and main quarto reports.

The following is a tabulated list of maps and reports:

MAPS.

1. Topographic maps, atlas sheet series (scales, 1 inch to 8 miles, 1 inch to 4 miles, and 1 inch to 2 miles, including five preliminary sheets)	55
2. Land classification sheets based on above (scale 1 inch to 4 miles)	30
3. Geologic sheets based on above (scales 1 inch to 8 miles, 1 inch to 4 miles, including two preliminary sheets)	13
4. Maps of all kinds, bound with reports	54
5. Special and miscellaneous maps (scales from 1 inch to 12 miles to 1 inch to 1,500 feet)	12
Total	164

REPORTS.

1. Regular quarto volumes	8
2. Miscellaneous quarto volumes	7
3. Annual reports, separately published	12
4. Special reports, folio and royal octavo	3
5. Miscellaneous pamphlet reports, octavo and duodecimo	11
Total	41

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*The project presented in 1872 for a connected and continuous survey, approved by act of June 10, 1872, estimated a cost of $2,500,000, spread over an interval of 15 years. Had not the appropriation been stopped in 1879 the field work for the whole area west of one-hundredth meridian could easily have been completed by 1887, if not earlier.

LAKE SURVEY.

While the admirable work of this office has been within areas east of the Mississippi, yet it has also successfully co-operated with certain western parties, in the establishment of telegraphic longitudes, results from which appear on page 763 *et seq.* (Professional Papers, Corps of Engineers, U. S. Army, No. 24; Primary Triangulation of the U. S. Lake Survey; Comstock, 1882.)

The observers at Detroit were Capt. H. M. Adams and Lieut. P. M. Price, U. S. Engineers, and assistants O. B. Wheeler and A. R. Flint. The latitudes and longitudes of twelve points are given: Four in Dakota, Wyoming, and Nebraska (Capt. W. S. Stanton, U. S. Engineers, observer); one in Nevada (Capt. W. A. Jones, U. S. Engineers, observer); one in Utah (Dr. F. Kampf, U. S. Geographical Survey, observer); one in Kansas (Lieut. E. H. Ruffner, U. S. Engineers, observer); and five in Texas (Lieut. William Hoffman, U. S. Army, observer).

In 1876 the duty of making a survey of the Mississippi River was placed upon the Lake Survey, which was commenced at Cairo, Ill., during the winter of 1876–'77, and base measuring triangulation, topographic, hydrographic, and precise leveling work was continued also from Memphis southward during two succeeding winters.

All of these results were availed of by the Mississippi River Commission Survey, including complete maps (topographic and hydrographic) of 40 miles of the river southward from Memphis.

MISSISSIPPI RIVER COMMISSION SURVEY.

This Commission, constituted by act of June 28, 1879, instituted a system of surveys not useful only to the proximate ends in view, but also in connection with the wider ultimate range of inquiry when necessary.

The U. S. Lake Survey, during the winter of 1876–'77, began a special survey of the Mississippi River (topographic and hydrographic) in the vicinity of Cairo, which was continued during the winters of 1877–'78 and 1878–'79, at and below Memphis, all of the work of which was availed of by the Mississippi River Commission.

It consisted of a developed line of secondary triangulation, resting upon secondary bases when necessary, principally from Cairo to the head of the Passes, about 1,100 miles. The triangulation at Cairo connects and depends upon a secondary base of the U. S. Lake Survey. Co-operation was extended during 1880 and 1881 by triangulation and hydrographic parties of the Coast and Geodetic Survey, as appears from the reports of this office and also that of the Commission.

Tertiary triangulation was availed of along certain reaches.

All existing survey data was utilized[*] and co-operation had with the Coast Survey as to the triangulation and precise leveling, which was carried from a beach point at the Gulf along the banks of the river northward to Fulton, Ill., and from thence to the level of Lake Michigan, at Chicago, where it is joined to the line of precise levels brought by the Lake Survey from tidewater at New York City.

The average closure of the triangles ranged from 2 to 6 seconds.

Topography consists of developing the shore line of the actual river, with its banks, tow-heads, chutes, islands, etc., also levees, elevations of banks, water surfaces, cross-sections of levees, etc., all resting upon the triangulation, with five-foot contours depending on numerous elevations (sketched) carried back an average distance of three-fourths of a mile each side.

All topographic work intermediate between △ stations was determined by stadia measurements frequently checked.

Nine principal trans-alluvial level lines were run to obtain information as to the alluvial bottom lands and their reservoir capacity; also similar levels over 160 miles between Lower Red River and the Atchafalaya.

Elevations by vertical angles (by circle or telescope level), all creeks and lakes, between bluffs and the river located.

Collections were made of reliable high-water marks of 1883.

The topography includes outlines of bluffs, old river lakes, and bayous, the Red River, and Cut-off Bayou to the main stream; also sloughs, swamps, fields, woods, and houses.

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[*] In 1879 the Coast Survey had published charts of the river between Point Houmas (72 miles above New Orleans) and the Gulf, showing depths and marginal topography.

Measurements made of caving and changes in sliding banks, with bank line, cross-section, and reliable elevations of old and new river banks. Difference of elevation determined between top and bottom of bluffs, with heights of tops above mean water surface; also connections with county and State lines and with township and section corners of public lands. The precise levels were run in duplicate, in opposite directions, with permanent beach marks every 3 miles.

Hydrography.—Soundings in boats for cross-sections of the river and its approaches for about every half mile, with intermediate lines across base. Cross-sections were repeated near the principal crevasses after the flood of 1882.

Profile of water surface for low water of 1883 from St. Louis to New Orleans was determined. Special hydrographic surveys made in vicinity of crevasses.

Resurvey made to determine the enlargement of the Atchafalaya. Besides normal sections in 1882 soundings were taken (1882) along the line of deepest water. In 1884 special surveys made above, below, and through cut-offs.

Observations made of flood escapes through crevasses; correct data obtained as to depths of bad bars at low water.

Longitudinal lines sounded along the thread of deepest water from Island No. 1 to Donaldson's Point, also 98 miles north of Caruthersville.

Physical inquiries extending to all the recognized phenomena likely to have a bearing upon problems of improvement were instituted.

Physical examinations of selected reaches, presenting locally and relatively the most widely contrasted elements of width, depth, and curvature, were made.

Stations for recording river elevations were maintained and increased where necessary, so as to trace the progress of floods and the principal features of the river slopes.*

The trigonometric stations have been marked by stones 3 feet long, dressed 6 by 6 inches at one end; balance rough, with top projecting a few inches from the ground.

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*Twenty gauges have been maintained continuously on the main river and its tributaries.

The precise level stations were marked by flat stones 18 inches square and 4 inches thick, with hole in center, into which a copper bolt is leaded. This is incased by a cast-iron 4-inch pipe 5 feet long, with elevations of top of pipe and stone both determined.

Computations.—The computations were usually made by angle adjustments by least squares for quadrilaterals and pentagons, with computations of lengths, and azimuths of the sides, and formation of equations of condition and their solutions.

Instruments.—The instruments employed were as follows: Triangulation, Troughton & Sims 12-inch and Gambey 10-inch theodolites, Repsold 12-inch and Pistor & Martins 5-inch universal instruments, Wurdemann-Gambey 10-inch and 6-inch transit theodolites, and ordinary transits. There were also Stackpole and Kern Y levels, with rods, ordinary and pocket sextants, chronometers, stadias, standard meter, iron standard bars, steel tapes, prismatic compasses, pedometers, and hand levels.

The cost of certain parts of the completed survey is stated at $169 per lineal mile and at $57 per square mile for topography alone, exclusive of the cost of all other branches.

Geographic co-ordinates (latitudes and longitudes) results of the triangulation may be found published in progress report, 1881, being Senate Executive Document No. 10, Forty-seventh Congress, first session; Appendix SS, Part III, Annual Report Chief of Engineers, 1883, pages 2158 *et seq.*; and Appendix TT, Part III, Annual Report Chief of Engineers, 1884, pages 2445 *et seq.*

Maps.—The map publications consist of detailed contour charts (3 feet and 5 feet intervals), scale 1 to 10,000; including outline and topographic maps, and those of the river lakes, the same reduced to 1 to 20,000; preliminary maps, 1 to 63,360; with a general map of the whole alluvial basin from Cape Girardeau to the Gulf (see tabular list of maps).

The Progress and Annual Reports have usually been published first as executive documents, appearing during the sittings of Congress, which have afterwards been incorporated in the Annual Report of the Chief of Engineers, as follows: Appendices SS, 1881; RR, 1882; SS, 1883; TT, 1884; WW and WW$_{10}$ 1885. The Annual Report for 1886 appears as

House Executive Document No. 30, Forty-ninth Congress, second session.

The survey is considered complete below Cairo; above Cairo the triangulation is carried to Keokuk, Iowa, the detailed field survey being complete for 25 miles above Cairo.

The first extension when made will be to complete topography and hydrography upward as far as the mouth of the Missouri, it being in contemplation finally to continue it as far as St. Paul, Minn.

MISSOURI RIVER COMMISSION.

Prior to 1884, commencing in 1878, the surveys on the Missouri River consisted of an accurate delineation of the shore line, islands, and sand bars, the general topographic features of the valley, and the line of bluffs bordering the same, the whole checked by a system of triangulation carried along the river banks.

Soundings were made, on lines normal to the current, from 500 to 1,500 feet apart; carefully checked levels were carried from Pierre to the mouth.

The results have been reduced and published as photolithographs, scale 1 inch to 1 mile. The Missouri River Commission commenced in 1884 a secondary triangulation of the river, to be carried from bluff to bluff, marked by permanent monuments and the establishments of permanent bench-marks, all to be connected with former surveys.

The monuments marking the triangulation points consisted of a stone 18 by 18 by 4 inches placed 3 feet 4 inches in the ground, in which was placed a 4-inch gas-pipe 3 feet long, the top covered with a cast iron cap, secured by a bolt and nut. (See Appendix XX, Annual Report Chief of Engineers, 1885, Part IV, pages 3015 *et seq.*)

SURVEYS FOR RIVER AND HARBOR IMPROVEMENTS.

These have been conducted at numerous points throughout the whole country, including frequent reaches of navigable rivers, also harbors and their approaches, but being for Engineers' purposes solely have been directed to the physical relations of channels and water-ways, within the purview of the improvements, and hence have been made with an eye single to these improvements. Immeciate results have always been required, and hence, while often possessed of much topographic and hydrographic detail, are possessed of no geographic connection (no latitudes, or latitudes being established as a rule) and are valuable more particularly in preliminary compilation. The plats are either published with the Annual Reports of the Chief of Engineers, in executive documents, or held as original drawings at the Engineer Department.

MAPS, ENGINEER DEPARTMENT.

The recompilation of the Western Territory Map, originally constructed and compiled at close of the Pacific Railroad surveys by Lieut. Warren, commencing in 1867, was the only general topographic map of this territory until a new compilation (scale 1 to 500,000) was begun in 1876, and published in 1879 as a photolithograph (scale 1 to 2,000,000). The compilation of a new outline map of our territory west of the Mississippi was commenced in 1880, the compilation completed in 1882, the same engraved and published in 1884 in outline, and in 1885 with hill work in color.

Special photolithographed maps (1 to 1,500,000) were issued in 1880, separately, as follows: Colorado, Oregon, Washington and Idaho, New Mexico and Arizona, California and Nevada.

A new map covering the entire territory of the United States, designed both for military and geographic purposes, had in 1869 been compiled and engraved. This was revised in 1874, and a new edition printed. This was further revised, and in 1877 again re-issued.

In 1882 a new outline map of the United States was commenced, and in 1885 engraved and issued.

In 1886 a new outline map of the United States (scale 1 to 2,000,000) was commenced, as also a compiled map of Central America (scale 1 to 1,250,000).

In 1881 an outline map of the United States (scale 1 inch to 52½ miles) showing location of works and surveys for rivers and harbors was issued.

From time to time many military topographic and geographic maps of various scales, usually prepared at the headquarters of military divisions and departments, have been published and issued either at the Engineer Department or at the above offices, as appears from the several Annual Reports of the Chief of Engineers. It has been impossible, for want of data, to name all of them, and it may be said that these are such current compilations, demanded by the commanding general, as means permit.

INTERIOR DEPARTMENT.

GEOLOGICAL EXAMINATION IN NEBRASKA, BY PROF. F. V. HAYDEN, 1867.

In 1867, when Nebraska was admitted as a State, Congress set apart the unexpended balance ($5,000) of the appropriation for legislative expenses of the Territory for a geological survey of the new State.

The examination was conducted by Dr. F. V. Hayden, who was assisted by Prof. F. B. Meek, and by Mr. James Stevenson as business agent. The sale, for a party of ten, from the subsistence stores of the Army was authorized.

The report of the work was made to the Commissioner of the General Land Office, and was devoted to the geological structure of Nebraska.

GEOLOGICAL EXPLORATION OF WYOMING, BY PROF. F. V. HAYDEN, 1868.

In 1868 $5,000 was appropriated to continue the work of geological exploration in Wyoming Territory.

The party consisted of nine persons and was organized at Cheyenne, Wyo.

The field work extended westward to Greene River. The geological structure along the line of the Union Pacific Railroad and along the Overland Stage Route was examined.

The Laramie Plains and North Park were visited and described.

The report of this work was also made to the Commissioner of the General Land Office.

GEOLOGICAL SURVEY OF THE TERRITORIES, BY PROF. F. V. HAYDEN, 1869.

In 1869 the work was placed under the supervision of the Secretary of the Interior, and an appropriation of $10,000 was made for a geological examination of Colorado and New Mexico.

This may be regarded as the proper commencement of the survey.

The field party consisted of eleven persons in all, including, besides Dr. Hayden, Mr. James Stevenson, managing director; Mr. Persifor Frazer, jr., mining engineer; Prof. Cyrus Thomas, entomologist and botanist, and Henry W. Elliott, artist.

The greater part of the outfit was furnished by the Quartermaster's Department, and such aid as was needed was supplied at the military posts en route.

The field labors commenced in the latter part of June at Cheyenne, Wyo., from which point a reconnaissance was made along the eastern edge of the Rocky Mountains via Denver, Central City, and Cañon City to Santa Fe, N. Mex.

Trips were made to the mines at the head of the Cache la Poudre River, the coal mines at South Boulder, the silver mines of Georgetown, the gold mines of Central City and Middle Park.

From Santa Fe the return was made via the Rio Grande through San Luis Valley, Poncho Pass, Arkansas Valley, and South Park to Denver.

The resulting report and all those thereafter were made to the Secretary of the Interior.

EXAMINATION OF 1870.

In 1870 the appropriation was $25,000.

The area explored comprised a portion of Wyoming Territory.

A reconnaissance was made from Cheyenne northward along the eastern base of the Laramie Range via the Chugwater, North Platte, and Sweetwater Rivers to South Pass.

Frequent excursions were made on each side of the route of travel, and the Sweetwater mines and the southern portions of the Wind River Mountains were visited.

From South Pass the party passed down the Little and Big Sandy Creeks to Green River, and thence by way of Church Buttes to Fort Bridger.

A permanent camp was established at the latter point, from which numerous excursions were made, especially to the Uintah Mountains, the northern slopes of which were explored.

From Fort Bridger the course was southward to Henry's Fork and via that stream to Green River City, on the Union Pacific Railroad.

From the latter place the old stage road was followed up Bitter Creek, over Bridger's Pass and the Medicine Bow Mountains, across the Laramie Plains, and through the Laramie Range via Cheyenne Pass to Cheyenne, the point of departure.

The party in the field in 1870 consisted of twenty persons, with Dr. F. V. Hayden in charge; James Stevenson, assistant; Henry W. Elliott, artist; Prof. Cyrus Thomas, agriculturist; William H. Jackson, photographer; John W. Beaman, meteorologist; Charles T. Turnbull, secretary; Arthur L. Ford, mineralogist; C. P. Carrington, zoologist; Henry D. Schmidt, naturalist, and L. A. Bartlett, general assistant.

Outfits and equipments were furnished by the Quartermaster's Department and assistance "by the military authorities of the west," which caused a "great saving to the appropriation."

EXAMINATION OF 1871.

In 1871 it was decided to carry on topographic work in connection with the geological explorations.

The plan adopted was that of a topographic reconnaissance—the reconnaissance of the immediate line of march, with the country in sight from it controlled by courses and distances, the former measured by compass, the latter by odometer, and the whole checked by sextant latitudes.

The party organized as follows, at Cheyenne, Wyo.: Dr. F. V. Hayden, geologist, in charge; James Stevenson, assistant; Henry W. Elliott, artist; Prof. Cyrus Thomas, agricultural statistician and entomologist; Anton Shouborn, chief topographer; A. J. Smith, assistant; William H. Jackson, photographer; George B. Dixon, assistant; J. W. Beaman, meteorologist; Prof. G. N. Allen, botanist; Robert Adams, jr., assistant; Dr. A. C. Peale, mineralogist; Dr. A. C. Turnbull, physician; with a number of general assistants, the entire field party numbering about thirty-six persons. The greater portion of the outfit (including horses, mules, wagons, and other equipments) were furnished from the Army, and aid, where possible, by the military authorities. Commissary stores were purchased at cost price, with the cost of transportation added. One company, Second Cavalry, under Captain Tyler and Lieutenant Grugan, was a joint escort to this party and those of Captains Barlow and Heap, U. S. Engineers. The escort officers were replaced at Yellowstone Lake by Lieutenant Doane.

The party proceeded by rail from Cheyenne to Ogden, in Utah, whence a reconnaissance was made with a wagon train northward via Cache Valley, Snake River Plains, and the Madison Valley, through Utah and Idaho into Montana as far north as Bozeman, in the Gallatin Valley. and thence to Boteler's ranch, on the Yellowstone River.

From the latter point a trip of some six weeks' duration was made with a pack-train to Yellowstone Lake and the geysers and hot springs on the Fire Hole or Upper Madison River (a portion of which region was afterwards set aside by Congress as the Yellowstone National Park).

The return trip was made along the Jefferson Fork of the Missouri and across the Snake River Valley to Fort Hall, in Idaho, and thence via Bear Lake Valley and Bear Lake to Evanston, Wyo., where the party disbanded for the season.

The amount appropriated was $40,000.

EXAMINATION OF 1872.

In 1872 two well-equipped parties were put in the field. The topographic work was improved by the addition of a running system of triangulation, which, in conjunction with the observations for latitude, were used in correcting the work.

The first, or Yellowstone division, was under the immediate charge of Dr. F. V. Hayden, with the following members: Adolf Burck, chief topographer; Henry Gannett, astronomer; A. E. Brown, assistant topographer; E. B. Wakefield meteorologist; Dr. A. C. Peale, mineralogist; W. H. Holmes, artist; Walter B. Platt, naturalist; W. B. Logan, secretary; and three general assistants.

The rendezvous for this division was at Fort Ellis, in Montana, from which point the trip to the Yellowstone Park was taken. The headwaters of the Yellowstone, Madison, and Gallatin Rivers were explored in much greater detail than during the previous year. The same assistance as that of the previous year was rendered by the military authorities.

The second, or Snake River division, was in charge of Mr. James Stevenson, and was constituted as follows: Prof. Frank H. Bradley, chief geologist; W. R. Taggart, assistant geologist; Gustavus R. Bechler, chief topographer; Rudolph Hering and Thomas W. Jaycox, assistant topographers; William Nicholson, meteorologist; John M. Coulter, botanist; Dr. Josiah Curtis, surgeon and microscopist; C. Hart Merriam, ornithologist; Campbell Carrington, naturalist; Robert Adams, jr., and others, general assistants. The superintendent of the Yellowstone National Park also accompanied the party. This division, starting from Fort Hall, in Idaho Territory, made a reconnaissance of the country between that post and the Yellowstone Park, including the sources of Snake River, and the Teton Mountains and the southern portion of the Park.

The appropriation for the year was $75,000.

UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES.

SEASON OF 1873.

In 1873 the field of work was transferred, and fuller and more detailed topographic observations, in charge of James T. Gardner, carried on in conjunction with the geological examination.

A connected survey, covering uniformly the whole country, controlled by a triangulation, took the place of the route reconnaissance of the previous years.

At the beginning of the work a base line was carefully measured near Denver, and the system of triangulation was expanded by well conditioned triangles. The triangulation was controlled by connection with stations at Denver, Colorado Springs, and Trinidad, the latitude and longitude of which were determined by the United States Coast Survey. The angles were measured with 8-inch theodolites, reading to ten seconds of arc. The mean error of closure of the triangles measured in 1873 is 10′ 3″.

The secondary triangulation was carried on by the topographers coincidently with the topographic work. The angles were measured with a 4-inch theodolite reading to minutes. The mean error of closure is about two minutes.

The topographic observations were made from commanding points, mainly from the stations in the secondary triangulation susceptible of location and were fixed in position by the intersections. All important streams were meandered. Heights were measured by the cistern barometer, and by vertical angles. The base barometer stations were so distributed, horizontally and in height, that any hypsometric work could be referred to a base in no case more than 50 miles distant nor differing in height more than 2,000 feet. All the high mountain peaks were carefully connected by vertical angles, and all barometric readings taken on them, were reduced to a common point, and then referred to the observations taken on the summits of Mount Lincoln or Pike's Peak as a base.

The work in Colorado began in 1873 with an appropriation of $75,000.

The principal triangulation party was in charge of James T. Gardner.

The eastern portion of the mountainous part of the State was embraced topographically and geologically by three divisions, which covered in all some 23,000 square miles. The first or Middle Park division was directed by Mr. A. R. Marvine, geologist, with G. R. Bechler as topographer and S. B. Ladd topographical assistant.

The area surveyed by this division was approximately a rectangular belt, the eastern end of which rested on the plains near Denver. This belt extended westward across the main chain of the Rocky Mountains to and including the Middle Park.

The second or South Park division was in charge of Mr. Henry Gannett, topographer, with Dr. A. C. Peale as division geologist, and Mr. W. R. Taggart as assistant. The area surveyed by them extended westward from the plains to the Elk Mountains.

The third or San Luis division was directed by Mr. A. D. Wilson, topographer. Mr. George B. Chittenden was assistant topographer, and Dr. F. M. Endlich division geologist.

The field occupied by this division was the southern portion of the eastern mountainous part of the State.

Besides the division just enumerated, there was a party of supervision, under Dr. F. V. Hayden, with Mr. W. H. Holmes as geological artist, and Mr W. H. Jackson photographer, and various assistants and collectors.

Second Lieut. William L. Carpenter, Ninth U. S. Infantry, accompanied the expedition as naturalist.

The same assistance as hitherto was afforded by the military authorities.

SEASON OF 1874.

In 1874 Congress appropriated $75,000 for the continuation of the work in Colorado, and the work was extended westward and southwestward, covering an area of 13,000 square miles. The divisions were late in reaching the field and were constituted as follows: Party of general supervision—Dr. F. V. Hayden, geologist in charge; W. H. Holmes, assistant geologist and artist; Mr. George B. Chittenden, topographer. This party was occupied mainly with the examination and mapping of the moraines of the Upper Arkansas Valley and the detailed examination of the Elk Mountains.

First division, A. R. Marvine, division geologist in charge; S. B. Ladd, topographer.

This division continued their work of 1873 westward.

Second division, Henry Gannett, topographer in charge; Dr. A. C. Peale, geologist. The area surveyed was that lying west of the Elk Mountains between the Grand and Gunnison Rivers.

Third division, A. D. Wilson, topographer in charge; Dr. F. M. Endlich, geologist. The work of the preceding year was extended westward and southward.

The party of primary triangulation was in charge of Mr. James T. Gardner, and measured a base in San Luis Valley, carrying also the triangulation over the southern part of the State.

The photographic and naturalist's division was under the supervision of Mr. W. H. Jackson, photographer. Mr. Ernest Ingersoll was naturalist.

Middle Park and the San Juan region were visited and particular attention paid to the cave dwellings and other ruins in southern Colorado.

Dr. Elliott Coues, surgeon U. S. Army, rendered valuable assistance in and contributions to the publications, commencing with this year.

SEASON OF 1875.

The appropriation for 1875 was $75,000, and work was resumed in the western part of Colorado. An area of 24,000 square miles was surveyed by the following divisions of the survey:

First or southern division, A. D. Wilson, topographer in charge; Dr. F. M. Endlich, geologist. This division was in the southern part of Colorado, mainly in the Sangre de Christo Range and the adjacent country.

Second or southwestern division, W. H. Holmes directing, with George B. Chittenden as topographer, continued the work of Mr. A. D. Wilson of 1874 to the westward. Mr. Holmes made also a special observation regarding the prehistoric remains of southwestern Colorado.

Third or Grand River division, with Henry Gannett, topographer, as director, and Dr. A. C. Peale as geologist, extended westward their work of the previous year.

Fourth division, in charge of G. R. Bechler, topographer, worked in the eastern part of the State, connecting by meanders and triangulation of several isolated areas surveyed during the previous years.

The principal triangulation was under the supervision of James T. Gardner.

The photographic and naturalists party was directed by W. H. Jackson, with Ernest Ingersoll as naturalist. They spent most of the season in southwestern Colorado investigating the extent and distribution of the ruins in that region. Their field was extended also to include the Moquis Pueblos.

SEASON OF 1876.

In 1876 an appropriation of $65,000 was made to complete the survey of Colorado, of which about 10,000 square miles remained to be examined. The field season was short, but the work was accomplished.

The primary triangulation was completed by Mr. A. D. Wilson, who was accompanied by Mr. W. H. Holmes, for the purpose of taking a general view (for comparison) of the two great plain belts that lie one along the east and the other along the west base of the Rocky Mountains.

The first or Grand River division, directed by Henry Gannett, with Dr. A. C. Peale, geologist, completed the western central portion of the State, and also surveyed a small area lying north of Grand River.

The second or White River division was in charge of George B Chittenden, topographer, accompanied by Dr. F. M. Endlich as geologist, and worked south of White River, extending the survey over into Utah.

The third or Yampah division was directed by G. R. Bechler; Dr. C. A. White was the geologist. The field of work was the extreme northwestern portion of Colorado, lying between the Yampah and White Rivers, which area was satisfactorily completed.

SEASON OF 1877.

Examinations were carried northward into Wyoming and Idaho Territories, beginning at the northern line of the work of the exploration of the 40th parallel. During the season 30,000 square miles, embracing parts of Wyoming, Idaho, and Utah, were covered. The following parties were put in the field:

First, party of primary triangulation, in charge of A. D. Wilson, chief topographer.

Second, Green River division, in charge of Henry Gannett, topographer, with Dr. A. C. Peale, geologist. The area surveyed was the Green River Basin and the country westward of the Portneuf River.

Third, Sweetwater division. in charge of George B. Chittenden, topographer, with Dr. F. M Endlich as geologist. This division surveyed the area east of the Green River Basin lying between the Union Pacific Railroad and the Wind River and Sweetwater Mountains, including the latter range and a part of the former

Fourth, Teton division, in charge of G. R. Bechler, topographer, with Orestes St. John, geologist. The region surveyed by this division was directly north of that occupied by the Green River division, and included the Teton Mountains and a portion of the Snake River Plains.

There were also several special parties in the field, and among them one for critical paleontologic work, under Dr. C. A. White, who examined the geological formations that lie on both sides of the Rocky Mountains and on the north and south of the Uintah Mountains.

Mr. W. H. Jackson, with the photographic division, made a tour through the northern part of New Mexico and the northeastern part of Arizona, securing material for the illustration of methods of building employed by the Pueblos or town-building Indians.

On account of office work—superintending publications—Dr. Coues, surgeon U. S. Army, could not perform extended field work.

SEASON OF 1878.

In 1878 the work of the preceding year was extended northward, and included the Yellowstone National Park. The total area comprised was 7,000 square miles.

The appropriation for the year was $75,000, and four parties were put in the field, so constituted that they could be divided as the work required. They were made up as follows:

First, party of primary triangulation; A. D. Wilson, chief topographer, in charge.

Second, Yellowstone Park division; Henry Gannett, topographer, in charge. W. H. Holmes was geologist of the division, and investigated the general geological structures of the Park. Dr. A. C. Peale was also a member of the division, and made a special examination of the hot springs and geysers of the Park.

Third, Teton division; F. A. Clark, topographer in charge; O. St. John, geologist. This division surveyed the northern end of the Wind River Mountains, the Gros Ventres, Shoshone, and Owl Creek Ranges, and a part of the Snake River Valley.

Fourth, photographic division; W. H. Jackson, photographer, in charge. This party was occupied in the Park and in the Wind River Mountains.

Nine maps (pocket form) accompanied the Annual Report of 1878, as follows:

No. 1. Economic map of portions of Wyoming, Idaho, and Utah. Scale, 1 inch to 8 miles.
No. 2. Geologic map of portions of Wyoming, Idaho, and Utah. Scale, 1 inch to 8 miles.
No. 3. Geologic map of part of central Wyoming. Scale, 1 inch to 4 miles.
No. 4. Geologic map of parts of western Wyoming and southeast Idaho. Scale, 1 inch to 4 miles.
No. 5. Geologic map of parts of western Wyoming, southeast Idaho, and northeast Utah. Scale, 1 inch to 4 miles.
No. 6. Geologic map of Yellowstone National Park. Scale, 1 inch to 2 miles.
No. 7. Topographic map of central Wyoming. Scale, 1 inch to 4 miles (contours, 200 feet).
No. 8. Topographic map of part of western Wyoming and southeast Idaho. Scale, 1 inch to 4 miles (contours, 200 feet).
No. 9. Topographic map of part of western Wyoming, southeast Idaho, and northeast Utah. Scale, 1 inch to 4 miles (contours, 200 feet).

PUBLICATIONS.

The publications of the Geological and Geographical Survey of the Territories may be grouped under the following:

Annual reports (octavo).—There are twelve regular, beginning with 1867 and ending with 1878. There is also a report of the first three in one volume, and also two preliminary reports (viz, those for 1877 and 1878) and a supplement to the fifth annual, making in all sixteen publications of this class.

Bulletins (octavo).—There are six volumes of the Bulletin, which include twenty-seven bulletins issued separately.

Miscellaneous publications (octavo).—There are twelve of these publications, independent of each other but forming a regular series, numbered from I to XII, consecutively. As there are three editions of No. I and two of No. V, the total number is fifteen.

Monographs (quarto).—The quarto series of final reports already published includes eleven volumes. These are as follows: Vol. I, Fossil Vertebrates, Leidy, 1873. Vol. II, Cretaceous Vertebrata, Cope, 1875. Vol. III, Book I, Tertiary Vertebrata, 1884. Vol. IV, Miocene Vertebrata, Cope, (unpublished), 1887. Vol. V, Zoology, Thomas, 1873. Vol. VI, Cretaceous Flora, Lesquereux, 1874. Vol VII, Tertiary Flora, Lesquereux, 1878. Vol. VIII, The Cretaceous and Tertiary Floras, Lesquereux, 1883. Vol IX, Invertebrate Paleontology, Meek, 1875. Vol. X, Geometrical Moths, Packard, 1876. Vol. XI, North American Rodentia, Coues & Allen, 1877. Vol. XII, Fresh Water Rhizopods, Leidy, 1879; and Vol. XIII, Fossil Insects, Scudder (unpublished), 1887.

Unclassified publications.—This class does not form any regular series, and numbers fifteen in all, ranging in size from 18° to folio.

Maps.—Some of the published maps form parts of the various reports, while others were issued separately. Of the latter, some of the principal ones are as follows:

1871.—General map in colors, scale 1 inch to 10 miles, of portions of Idaho, Montana, and Wyoming, compiled, including work of that year.

1872.—Map of vicinity of headwaters of Snake River (Idaho, Wyoming, and Montana), scale 1 inch to 5 miles, brush work for hills; and map of Madison, Gallatin, and Upper Yellowstone drainage basins, scale 1 inch to 4 miles, sketchy contours, approximating 100 feet. Both colored, and issued as geological maps. General geologic map of the area explored and mapped * * * 1869 to 1880, scale 1 inch to 41.03 miles, was also issued. The principal map publication, however, was an atlas of Colorado (double folio), in 1878, consisting of 20 sheets, i. e., engraved title page, and legend sheets; four general sheets, 1 inch to 12 miles each, covering all of Colorado, (1) Triangulation, (2) Drainage, (3) Economic, and (4) General Geologic; six detailed topographic sheets, 1 inch to 4 miles, upon which are based six geologic sheets in colors, each sheet embracing 2½ degrees of longitude and 1¼ degrees of latitude; also, two sheets of geologic sections and two of panoramic views.

The whole presents the results of the field work from 1873 to 1876, inclusive, and, besides Colorado, embraces small adjacent portions of Utah, Arizona, and New Mexico.

A brief partial list of publications of this work is found in its catalogue of publications, second edition (revised to December 31, 1876); also House Executive Document No. 81, Forty-fifth Congress, second session (1878).

A reference to the methods employed to secure the topographic field data upon which to base a topographic map to receive the geologic and other colors, in and subsequent to 1873, will be found in Annual Report, 1873 (p. 627 *et seq.*), by James T. Gardner, and Annual Report, 1876 (p. 275 *et seq.*), by A. D. Wilson.

Commencing in 1867, the object of the observations by and under Dr. Hayden were the collection of data possible in a rapid geologic reconnaissance, supplemented by topographic reconnaissance data commencing in 1871, and subsequently more ample topographic details, referred to a field triangulation, graphically reduced, the whole resting on initial check points determined astronomically by the Coast Survey and quite similar to the work prosecuted in the fortieth parallel geological exploration.

The principal instruments used when the topographic work reached its best stage were 8-inch Wurdemann theodolites graduated to 10 minutes and reading to 5-seconds, gradientas, steel tapes, compasses and odometers, cistern and aneroid barometers with hygrometers.

Connection was made with Coast Survey astronomic stations at Denver, Colorado Springs, and Trinidad, Colorado. Six readings were taken for main triangulation stations and azimuths; with 10″.3, stated as error of closure for these triangles and 2′ for those subsidiary.

Determinations of position for the Colorado work are found in the Annual Report for 1876, p. 285 *et seq.*, and for that in Wyoming, Idaho, and Utah in the Annual Report for 1877, p. 661. The elevations determined by this survey (since compiled into the Dictionary of Altitudes, by Gannett) are referred to by volume and page in the following list. Only the first pages of continuous references are given: 1871, p. 521 *et seq.*; 1872, p. 799 *et seq.*, 813 *et seq.*; 1873, p. 657 *et seq.*, 667, 675, and 678.; 1874, p. 429 *et seq.*, 441, 446, and 492.; 1875, p. 299, 300, 342, 362 *et seq.*, 388, 408, 418, 440; 1876, p. 336 *et seq.*, 357 *et seq.*, 377; 1877, p. 681 *et seq.*; 1878, p. 459 *et seq.*

The total area reported by Hayden as having been covered topographically is 107,000 square miles, of which 37,000 square miles lie north and 70,000 square miles south of the Union Pacific Railroad.

The last field season was that of 1878, subsequent to which office reductions were continued, while it would appear from the following that in the main any unfinished results were transferred to the Geological Survey.

In the prefatory note to Vol. VIII, Floras (Lesquereux), the Director of the Geological Survey states that "on the 27th of September, 1882, at the request of Dr. F. V. Hayden, the completion of the publication of the U. S. Geological and Geographical Survey of the Territories, formerly under his charge, was committed to the Director of the Geological Survey," by an order of the honorable the Secretary of the Interior.

The volumes thus referred to would appear to be Vols. III (except Book I) and IV, Vertebrata; and Vol. XIII, Fossil Insects.

The Director further states that "a portion of the unpublished materials of the Hayden Survey" was transferred to the Geological Survey, and that "all the field-notes and the manuscript notes" were thus transferred, and that "the present Geological Survey inherited all the unfinished topographic work of the Hayden Survey, but it did not inherit its natural history work and some of its work in paleontology."

He further states that the Hayden Survey abandoned the unfinished part of their work not germane to the present Geological Survey; i. e., the natural history part.

The following is a condensed list of maps and reports resulting from this exploration:

MAPS.

		Number.
1. General maps		3
2. Atlas of Colorado (scale 1 inch to 12 miles and 1 inch to 4 miles):		
1.	2	
2. Geology	4	
3. Population	6	
4. Geology	6	
5.	9	
		20
3. General, special, and sketch maps bound with reports		53
Total		76

REPORTS.

1. Annual reports, octavo	12
2. Bulletins, octavo	27
3. Miscellaneous, octavo	12
4. Monographs, quarto	11
5. Unclassified	15
Total	77

GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE ROCKY MOUNTAIN REGION.

Mr. J. W. Powell states (see House of Representatives Report, No. 612, Forty-third Congress, first session, pp. 46 and 48) that in the years 1867,[*] 1868, and 1869, he was exploring in western Colorado and eastern Utah, about the source of the Grand, White, and Yampah Rivers, under the auspices of the Smithsonian Institution and certain scientific societies.

In 1869 he made the descent of the Colorado River from Green River Station, Union Pacific Railroad, through and including the Grand Cañon to the mouth of the Rio Virgin. In 1871 his work relating to the exploration of the basin of the Colorado River was placed under the Secretary of the Interior.

The object of the examination, beginning with a general exploration, seems to have been developed to embrace more or less definitely the branches of geology, topography, natural history, including ethnology—patterning somewhat after the geologico-topographic reconnaissance inaugurated by Clarence King in the exploration of the fortieth parallel.

In the later years of the work a classification of lands was attempted, to determine the position and extent of the irrigable, timber, mineral, and waste lands[†]

The total area explored, examined, or surveyed, suitable for publication in map form, by and under the direction of Mr. Powell, from the time of taking the field in 1867 to the close of the field duties of this expedition in 1878 (data from which is now being utilized by the Geological Survey), is stated by him (page 47, Senate Miscellaneous Document No. 82, first session Forty-ninth Congress) at 67,000 square miles.

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[*] During 1867, by authority, rations for twelve men were purchased from the Army Subsistence Department. Subsequently they were furnished for twenty-five men at the expense of the War Department.

[†] One sheet of the atlas of the Uintah Mountains shows classification colors for small detached areas.

SEASON OF 1870.

Mr. Powell states that the total area explored and surveyed during this season, in northern Arizona and southern Utah, was 6,000 square miles, and that the professional personnel were: J. W. Powell, geologist, in charge; A. H. Thompson, geographer; F. M. Bishop and W. H. Graves, topographers; also one chief packer, one teamster, three employés, and from two to ten others, temporarily, as guides and hunters. In pursuance of joint resolution approved June 11, 1868, rations were issued by the commissary branch of the War Department for twenty-five men for the years commencing 1868 and ending in 1878.

The instruments used were, as found stated in the several reports, zenith telescopes, theodolites, sextants, gradientas, wooden rods, steel tapes, compasses, barometers, and hygrometers, part of which were borrowed from the Engineer Department.

The route of the reconnaissance extended from Salt Lake City to the Cañons of the Colorado, thence eastward to the Moqui villages, disbanding at Old Fort Defiance December 5, 1870.

SEASON OF 1871.

Professional personnel: J. W. Powell, geologist, in charge. J. F. Stewart, assistant geologist; A. H. Thompson, geographer; F. M. Bishop, F. S. Dellenbaugh, and S. V. Jones, topographers; E. O. Beaman, photographer; J. K. Hillers, assistant photographer; also W. C. Powell, F. A. Richardson, and A. J. Hatten as general assistants, with one chief packer, 13 temporary employés, and a number of Indians as guides, hunters, and messengers

Area explored and surveyed in southern Wyoming, Utah, and Arizona, 12,000 square miles.

The routes pursued were by boat, leaving Green River May 22, descending the Colorado to the mouth of the Paria, with land work for a narrow belt on either side, thus gathering material for a reconnaissance map.

A preliminary report to the end of 1871 appears as House Mis. Doc. No. 173, Forty-second Congress, second session (1872).

SEASON OF 1872.

Professional personnel: J. W. Powell, geologist, in charge; A. H. Thompson, geographer; S. V. Jones and F. S. Dellenbaugh, topographers; J. K. Hillers, photographer; also W. C. Powell, A. J. Hatten, George Adair, Jacob Hamlin, George Riley, Nathan Adams, John Renshawe as general assistants, 18 temporary employés, with from 2 to 20 Indians as guides, hunters, and messengers.

Area surveyed in Utah and Arizona, 8,000 square miles.

The principal work for the year was in the Henry Mountains and vicinity.

A partial report, of July 17, 1873, appears as House Mis. Doc. No. 76, Forty-second Congress, third session (1873).

SEASON OF 1873.

Professional personnel: J. W. Powell, geologist, in charge; A. H. Thompson, geographer; J. H. Renshawe, topographer; J. K. Hillers, photographer; also, Nathan Adams, Joseph Haycock, George Adair, and Jacob Hamlin as general assistants, with temporary employés and a number of Indians.

Area surveyed in southern Utah and northern Arizona, 6,000 square miles.

A third preliminary report was submitted to the Secretary of the Smithsonian Institution and by him to the House of Representatives (8°, pp. 36, Washington: Government Printing Office. 1874), containing a summary of all work then executed.

SEASON OF 1874.

Professional personnel: J. W. Powell, geologist, in charge; Edwin E. Howell, assistant geologist; A. H. Thompson, geographer; J. H. Renshawe, W. H. Graves, and H. C. DeMotte, topographers; O. D. Wheeler, assistant topographer; J. K. Hillers, photographer.

Area surveyed in Wyoming, Utah, and Arizona, 15,000 square miles.

SEASON OF 1875.

Professional personnel: J. W. Powell, geologist, in charge; G. K. Gilbert, Capt. C. E. Dutton (U. S. Army), and C. A. White, assistant geologists;

A. H. Thompson, geographer; Robert Bell, J. H. Renshawe, and W. H. Graves, topographers; O. D. Wheeler, assistant topographer; J. K. Hillers, photographer.

Area surveyed in Wyoming, Utah, and Arizona, 10,000 square miles.

SEASON OF 1876.

Professional personnel: J. W. Powell, geologist, in charge; G. K. Gilbert, Capt. C. E. Dutton (U. S. Army), and C. A. White, assistant geologists; A. H. Thompson, geographer; J. H. Renshawe and W. H. Graves, topographers; O. D. Wheeler, assistant topographer; J. K. Hillers, photographer.

Area surveyed in Wyoming and Utah, 10,000 square miles.

This area is situated between the Wahsatch Mountains on the west and the Green and Colorado Rivers on the east and southeast.

SEASON OF 1877.

Professional personnel: J. W. Powell, geologist, in charge; G. K. Gilbert and Capt. C. E. Dutton (U. S. Army), assistant geologists; A. H. Thompson, geographer; J. H. Renshawe and W. H. Graves, topographers; O. D. Wheeler, assistant topographer.

Area surveyed in Utah, 10,000 square miles.

This work, in common with the greater share of all that executed by this expedition, is situated in the basin of the Colorado of the West, above the mouth of the Grand Cañon.

A brief report of operations for 1876 and 1877 was submitted November 25, 1877, to the Secretary of the Interior (8°, pp. 19, Washington: Government Printing Office, 1877), in which reference to ethnologic work, afterwards merged into the Bureau of Ethnology, is made.

SEASON OF 1878.

Professional personnel: J. W. Powell, geologist, in charge; G. K. Gilbert and Capt. C. E. Dutton (U. S. Army), assistant geologists; S. H. Bodfish, J. H. Renshawe, and O. D. Wheeler, topographers; P. B. Wright, W. A. Phillips, —— Tipton, and F. P. Morgan, assistant topographers; J. K. Hillers, photographer.

Area surveyed in Utah and Arizona, 10,000 square miles.

The above was the final season of field work for this expedition.

A communication regarding the continuation of ethnologic researches appears as House Miscellaneous Document No. 35, second session Forty-sixth Congress (1880).

Independent of the progress reports already mentioned the following quartos were issued:

Exploration of the Colorado River of the West, Powell, 1875, pp. 291, with 2 maps; Geology of the Uintah Mountains, Powell, 1876, pp. 218, with folio atlas; Geology of the Henry Mountains, Gilbert, 1877, pp. 160, with 5 plates and maps, second edition 1880; Lands of the Arid Region, Powell, 1878, pp. 195, with 3 maps, second edition 1879; and also Geology of the High Plateaus of Utah, Dutton, 1880, pp. 264, with folio atlas.

In 1880 three quarto volumes had issued from the ethnological branch, which later became a separate office, with its annual and other reports; but these results are not germane to this memoir, which for its main object has the analysis of the geographical foundation of national or Government maps, which, to be intelligible and homogeneous, should have sifted from it all the natural history portions, and remain more as an exponent of the mathematical field and office parts of topography and geography and their artistic delineation, and publication. Other than the maps accompanying reports, six preliminary sheets were issued; also four relief maps and two stereograms of the Grand Cañon, High Plateaus, and Henry Mountains were prepared for distribution to colleges and libraries.

A part of the topographic work was published in the atlas accompanying the report upon the Uintah Mountains and that upon the High Plateaus.

Mr. Gannett states, with regard to the topography, that "it has been republished entire by the present survey," *i. e.*, the Geological Survey.*

So far as can be ascertained no geographic positions (latitudes and longitudes) were published by this office. The same may be said with regard to altitudes, except such as appear on published maps.

A general reference to progress and results of the work may be found in House Executive Document No. 80, Forty-ninth Congress, second session.

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* Of the eighty-seven topographic base maps issued (April, 1887) for geologic purposes twenty-three are referred to on the face of each sheet as having been supplied in part or whole from the above work.

Tabulated list of maps and reports.

MAPS.			No.
1. Preliminary sheets		......	6
2. Accompanying reports:	1. Topographic	1	
	2. Geologic	14	
	3. Economic	2	
Scale 1 to 1,000,000, 1 inch to 16 miles, and 1 inch to 4 miles (principally).	4. Miscellaneous and sections	19	
	5. Maps and plates	5	
			41
Total		......	47
REPORTS.			
1. Annual and Progress			5
2. Quartos			5
3. Miscellaneous pamphlets			2
Total			12

(Also six volumes on ethnological subjects.)

Upon the close of this work, as stated by Mr. Powell in his letter of May 21, 1886, to Senator Allison, "all of the material, embracing collections of fossils, minerals, and rocks, and all field-notes of the geologist, and all topographic manuscript maps, together with the field-notes, computations, etc.," were transferred to the U. S. Geological Survey.

GEOLOGICAL EXAMINATION OF THE BLACK HILLS OF DAKOTA, BY W. P. JENNEY, E. M., AND H. NEWTON, E. M., 1875.

The parties conducting this examination left Cheyenne, Wyo., for the northward May 27, 1875. The object of the expedition, in accordance with letter of instructions of Commissioner of Indian Affairs of March 27, 1875, was "to obtain, pending certain negotiations for the cession of the Black Hills by the Sioux Indians, the true facts regarding the nature and value of the mineral deposits" having been lately discovered in that region.

The route to Fort Laramie (where the escort was joined) was by the usual traveled road from Cheyenne, the former point being left on May 24. The Hills were reached via Raw-Hide Butte and Old Woman's Fork.

Camp was made on the East Fork of the Beaver on June 3, from which point the instrumental work was begun, a permanent camp being at once established on French Creek, from whence operations were carried on by two parties. Succeeding bases of supplies were established as the work proceeded to the northward until the examination embraced the entire area of the Black Hills between the forks of the Cheyenne.

The routes within the Hills do not appear in detail. The area of the Black Hills, as stated by Mr. Newton in his report, aggregates 5,000 square miles.

The object of the expedition having been accomplished, the parties rendezvoused at the mouth of Rapid Creek, on the South Fork of the Cheyenne, preparatory to return march to Fort Laramie (via White River and Spotted Tail and Red Cloud Agencies), which point was reached on October 14, after an absence of four months and twenty days.

The professional work was carried on by W. P. Jenney, E. M., geologist, in charge, assisted by H. Newton, E. M., geologist; V. T. McGillycuddy, M. D., photographer; Capt H. P. Tuttle, astronomer; and W. F. Patrick, E. M., together with eleven miners and laborers.

The party was accompanied by a military escort of fully four hundred men, with a train of seventy-five wagons, in command of Lieut. Col. R. J. Dodge, Twenty-third Infantry, with Lieut. M. F. Trout, Ninth Infantry, as adjutant; Lieut. J. F. Trout, Twenty-third Infantry, as acting assistant quartermaster; Lieut. J. G. Bourke, Third Cavalry, topographer; and Assistant Surgeons Jaquette and Kane. The above escort consisted of two companies of the Ninth Infantry, under Capts. A. H. Bowman and S. Munson and Lieut. H. De Lany; two companies of the Second Cavalry, under Capt. E. J. Spaulding and Lieuts. C. T. Hall, J. H. Coale, and F. W. Kingsbury; four companies of the Third Cavalry, under Capts. W. Hawley, G. Russell, and H. W. Wessells and Lieuts. A. D. King, R. E. Whitman, James Lawson, J. E. H. Foster, and C. Morton.

Thanks are rendered in the final report for the hearty co-operation of the several officers, as well as a recognization of topographic assistance by Lieutenants Morton and Foster.

The instruments used were one transit theodolite, one surveyor's transit, one sextant, two marine and one pocket chronometers, two mountain and five aneroid barometers and thermometers. These (except the chronometers) were transported while in the Hills upon pack animals.

Topographic observations were made by the reconnaissance method, distances being estimated by time, courses, and topographic features observed with a prismatic compass.

Longitude was determined by chronometric differences,[*] and sextant observations were made for latitude. Triangulation, starting from an astronomic base (there being no measured base), was made to include the principal peaks.

A preliminary report, accompanied by a small preliminary map by Dr. McGillicuddy, was made by Mr. Jenney to the Office of Indian Affairs, and appeared on page 181 of the Annual Report of the Commissioner (1875).

A subsequent report by Mr. Jenney to the Indian Office, entitled: "The Mineral Wealth, Climate and Rain-fall, and Natural Resources of the Black Hills," appears as Senate Ex Doc. No 51, Forty-fourth Congress, first session (1876), with same map as in preliminary report (scale 1 inch to 8 miles).

A preliminary report on the paleontology of the Black Hills, by R. P. Whitfield, was printed as a pamphlet in July, 1877, by the Geological and Geographical Survey of the Rocky Mountain region.

The final report in quarto form, edited by Mr. G. K. Gilbert, on the geology and resources of the Black Hills of Dakota, by H. Newton, E. M., and W. P. Jenney, E. M., with an atlas, was published in 1880, under the auspices of the Geological and Geographical Survey of the Rocky Mountain Region. This volume contains, besides the contributions of Newton revised and edited by Mr. Gilbert, and that of Jenney substantially as found in his earlier report, others in the following order: On paleontology, by R. P. Whitfield; on microscopic petrography, by John H. Caswell; on botany, by Prof. Asa Gray; and on astronomy and barometric hypsometry, by H. P. Tuttle. On May 28, 1879, the results of this exploration were transferred to the survey of the Rocky Mountain region, by direction of the Secretary of the Interior.

Mr. Newton revisited the Black Hills in 1877, to repeat certain of his observations and record the results of the rapidly developing mining industry, where he died from typhoid fever, at Deadwood, August 5, 1877; hence the revision of his manuscript by Mr. Gilbert as stated.

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[*] The errors of the longitudes were afterwards corrected by a reference to points established on the eastern boundary of Wyoming, near "Camp Jenney" of the expedition; finally, by telegraphic longitudes of Deadwood and other points within the Hills, determined by Captain Stanton, Corps of Engineers, in 1877.

Maps.—The following are the maps known to have been separately issued:

LIST OF MAPS RESULTING FROM THE GEOLOGICAL EXPLORATION OF THE BLACK HILLS.

Title.	Author.	Date.	Scale.	No. of sheets.	Size within border.	Area in sq. ms. Approx.	Hill work. How represented.	Mode of reproduction.
Topographical map of the Black Hills.	Jenney and others.	1875	1″=8 ms.	1	17¾″ x 15¼″	9,300	Hachures.	Lithography.
The same.	....do	1875	1″=4 ms.	1	35″ x 31″	9,300	....do	Do.
Black Hills of Dakota (to accompany report of Henry Newton, E. M., etc.).*								
1 sheet, bird's-eye view of the Black Hills.*	....	1875	....	3	27¾″ x 19¾″	......	....	Colored lithograph.
1 sheet, Black Hills of Dakota.*	....	......	1″=4 ms.	...	35″ x 28″	9,216	Hachures.	Photolithograph.
1 sheet, Black Hills of Dakota (geologically colored).*	....	......	1″=4 ms.	...	35″ x 28″	9,216	Contours.	Colored photolithograph.

* In atlas.

RÉSUMÉ.

The topographic map (scale 1 inch to 4 miles) shows this class of observations to have extended over part, it not all, of an area of 9,300 square miles. The geological map (based upon the above) embraces an area of 9,216 square miles. The results, independent of those shown in the report of Newton on geology, Jenney on resources, and Whitfield, Caswell, and Gray on the natural history collections made, and the triangulation and topographic detail for the maps by Dr. McGillicuddy, as shown in report of Mr. Tuttle, are, longitudes 24,* latitudes 97, altitudes 93, and variations 13 in number.

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* These longitudes were found by Mr. Tuttle in 1877, by reference to points on eastern boundary of Wyoming, to be 4′ 47″ too far east; a further correction was introduced by a reference to telegraphic longitudes, established the same year by Stanton at Deadwood and other points within the Hills.

Chapters on the Dakota Indians by Mr. Newton were reserved for publication by the Bureau of Ethnology.

The following was expended in field work (see House Ex. Doc. No. 80, Forty-fifth Congress, second session): By direct appropriation, $14,000; indirect appropriation (allotted from "beneficial object fund for certain tribes of Northern Sioux"), $11,000; total, $25,000.

Wagons, camp equipage, and horses were loaned by the Quartermaster's Department, arms were loaned by the Ordnance Department, and rations purchased from the Commissary Department at cost. The cost of the escort was purely a military expense.

SUBDIVISION OF THE PUBLIC LANDS.

Of the 971,174,878 acres reported by the Land Office as having been subdivided June 30, 1886, 724,529,431 acres lie west of the Mississippi, while of the 844,329,269 acres then remaining unsurveyed all except 7,252,857 acres (Florida) belongs to the same territory, including, however, 369,529,600 acres (estimated) for Alaska, where these surveys have not yet been commenced. It appears that the law requires the establishment of no latitudes, longitudes, or altitudes in connection with these surveys, neither has it been the custom to conduct systematic topography, the latter being simply planimetric without a geographic basis; hence the results of the Land Office surveys, so far as relates to their uses in the compilation of general topographic and geographic maps, are but preliminary, on account of the above deficiencies, the available data being only such minor details as can be adjustetd to known geographic co-ordinates. For preliminary field and subsequent office plats they have, however, furnished valuable information.

BOUNDARIES OF STATES AND TERRITORIES.

These lines, when bounding States cut out of the public domain west of the Mississippi, were for a number of years run and marked by officers of Topographical Engineers, but immediately prior and subsequent to the late war they have been demarked under the General Land Office by contractors who have secured the services of competent astronomers and surveyors, employed under the authority of the Secretary of the Interior.

The following is a tabulated list of certain of these boundaries furnished by the Commissioner of the General Land Office:

State and Territorial boundaries surveyed under the direction of the General Land Office, between 1857 and 1880.

Boundary.	Names of surveyors and astronomers.	Date of survey.	Length of line measured.			Cost of survey.
			mls.	chs.	lks.	
West boundary of Minnesota.*	Chauncey H. Snow and Henry Hutton	1859	128	33	91	$5,000.00
Washington and Oregon.	Daniel G. Major (F. G. Hesse and John Major, assistants).	1864	96	57	00	4,500.00
North boundary of California.	Daniel G. Major (John J. Major, assistant).	1868–'69	212	40	00	12,750.00
Oregon and Idaho	Daniel G. Major	1867	124	17	02	7,452.77
North boundary of New Mexico.	Ehud N. Darling (J. Weissner and Alonzo Mace, assistants).	1868	331	60	00	19,000.00
West boundary of Nebraska.	O. N. Chaffee	1869	207	22	26	7,804.46
South boundary of Nebraska.†	O. N. Chaffee	1869	104	72	07	
East boundary of Nevada.	Isaac E. James (J. T. Gardner, assistant).	1870	401	50	56	10,625.00
Utah and Idaho	Daniel G. Major (John J. Major, assistant).	1871	153	56	00	6,480.00
East boundary of California.	Alexander W. Von Schmidt	1872–'73	611	75	77	40,750.32
West boundary of Kansas.	John J. Major	1872	207	26	00	8,293.00
North boundary of Nevada.	Daniel G. Major (John J. Major, assistant).	1872–'73	304	62	00	15,401.11
South boundary of Wyoming.	Alonzo V. Richards (T. H. Safford and A. MacConnel, assistants).	1873	367	48	81	22,056.61
West boundary of Wyoming.	Alonzo V. Richards (Augustus MacConnel, assistant).	1874	277	72	66	13,850.00
Part south boundary of Colorado.‡	John J. Major	1873–'74	57	04	50	2,282.25
Part east boundary of New Mexico.§	John J. Major	1873–'74	34	40	00	1,380.00
North boundary of Nebraska.	Chauncey Wiltse (E. P. Austin, assistant).	1874	224	12	20	8,069.49
Washington and Idaho.‖	Rollin J. Reeves and C. S. Denison	1873	176	40	00	10,590.00
Arizona and New Mexico.	Chandler Robbins (John H. Clark, assistant).	1875–'76	390	48	31	27,342.27
Arkansas and Indian Territory.	Henry E. McKee	1877	196	75	83	11,805.48
Wyoming and Dakota.	Rollin J. Reeves (Horace P. Tuttle, assistant).	1877	138	32	00	7,000.00
Colorado and Utah	Rollin J. Reeves (Horace P. Tuttle, assistant).	1878–'79	276	51	66	15,000.00
North boundary of Wyoming.	R. J. Reeves (H. P. Tuttle and C. M. Stephens, assistants).	1879–'80	346	42	00	20,000.00

* This survey included only that part of the line not marked by natural boundaries.

† 41° north latitude, from 25° to 27° longitude west from Washington. A survey of the boundary between Kansas and Nebraska was made between November 16 and December 5, 1854, by John P. Johnson, surveyor (result not available); the initial point being the intersection of the 40th parallel with the Missouri River, having been previously determined in 1854 by Capt. Thomas J. Lee, Topographical Engineers.

‡ 37° north latitude, from 25° west from Washington to 103° west from Greenwich.

§ 103° west from Greenwich, from 36° 30′ north latitude to 37° north latitude.

‖ From confluence of Snake and Clearwater Rivers, north to 49° north latitude. Survey abandoned 2 miles south of 49° north latitude.

NOTE.—All the reports of the above boundary surveys are in manuscript only.

The western boundary of Missouri, from the Missouri River at the mouth of the Kansas in a straight line to the southern boundary of Missouri (177 miles), was run in 1824 by Joseph C. Brown. The boundary between Missouri and Iowa, being parallel of 49° 44′ 06″ N. latitude between Des Moines and the Mississippi Rivers, was established in 1837 (length 203 miles); in 1847 the boundary between Arkansas and Missouri—being the parallel of 36° N. latitude from the Mississippi to the St. Francis (36 miles 49.88 chains) and the parallel of 36° 30′ N. latitude from the St. Francis to the western boundary of Missouri (247 miles 44.41 chains).

That part of the eastern boundary of Colorado lying on the 25th meridian west from Washington, from latitude 40° to 41° N. (69 miles) was run in 1870 by O. N. Chaffee, surveyor.

The boundary between Dakota and Montana, being that part of the 27th meridian west of Washington between latitudes 45° and 49° N. (276 miles 26 chains) was determined in 1877 by Daniel G. Major, astronomer.

The two last above-named were under the auspices of the General Land Office, where it is presumed that the original records are to be found. The locus of the original records of the three others above is not known. It is believed that all of the original records of boundaries west of the Mississippi will be found either at the General Land Office or at the Engineer Department.

No data has been found available for the boundaries between Louisiana and Arkansas, Iowa and Minnesota, Minnesota and Wisconsin, and of the eastern line of the public land strip. It is believed that the boundaries between Arizona and Utah, and Montana and Idaho, have not yet been demarked, nor that part of northern Colorado adjoining Nebraska.

The survey of the 98th meridian west longitude from the Red to the Canadian River was made by Messrs. A. H. Jones and H. M. C. Brown (Daniel G. Major, astronomer), under a contract with the acting Commissioner of Indian Affairs, dated October 13, 1857. The length of the measured line was 93 miles and 38 chains. The record of the observations and results of the astronomer are believed to be in the Indian Bureau.

That part of the 100th meridian west longitude which lies between the southern boundary of the Cherokee country and the Red River was measured in 1859 by Messrs. A. H. Jones and H. M. C. Brown (Daniel G. Major, astronomer), under contract with the Indian Office. The original field-notes, showing that the survey was begun April 22 and completed May 11, 1859, the length of the measured line to be 109 miles 56.59 chains, and the reductions of the astronomer, are of record in the Indian Bureau. The above was adopted and made a part of the official boundary survey between the United States and Texas. (See Senate Ex. Doc. No. 70, Forty-seventh Congress, first session.)

Special surveys of Indian lands have been made by Daniel and John J. Major in the eastern Ute reservation of Colorado in 1881, with an initial point at Gunnison, and of boundaries of Indian reservations, and in the subdivision of Indian lands, but data there upon it has not been practicable to obtain.

UNITED STATES GEOLOGICAL SURVEY.

This office was created by appropriation act of March 3, 1879, and placed under a director, who "shall have the direction of the Geological Survey and the classification of the public lands, and examination of the geological structure, mineral resources and products of the national domain." Under this act a geologic-topographic reconnaissance work similar to that pursued by King in the geologic exploration of the 40th parallel, and also to some extent by Hayden and Powell, was begun west of the Mississippi River; while the words of an appropriation act of 1882 "to continue the preparation of a geological map of the United States" have been interpreted to authorize field work east of the Mississippi River, since which date similar operations have been conducted largely within that territory. The memoir herewith was intended only to bring a reference to the works down to January 1, 1880, and time and means alike forbid a tracing of this office, then but just begun, but now grown to large proportions. However, from the testimony of the Director (Mr. J. W. Powell, who succeeded Mr. Clarence King),* and the Annual Reports of the Survey, certain information regarding field operations and office results will be herewith found.†

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* See Senate Mis. Doc. No. 82, Forty-ninth Congress, first session.

† The progress of field triangulation to year ending June 30, 1886, will be found in report by Henry Gannett, in the Seventh Annual Report from this office, pp. 45 et seq.

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Following the scope given to geology by this office, it appears that a survey of the whole United States, consisting of a geologic examination, for the graphic illustration of which topographic maps as a base are specially produced, has been inaugurated.

These are not published as topographic maps for general distribution* (there being no authority therefor), but are to be issued, as prepared, with the geologic colors added. The Director states a considerable area as covered by the original observations of this office, but as regards results germane to the scope of this memoir of later works, i. e., astronomic, geodetic, trigonometric, topographic, and hypsometric, nothing yet published regarding results seems to define the exact value or extent of the latitudes, longitudes, and altitudes or the mathematical basis of the work.

The publications are more purely geologic, or of an allied character.

The results can much better be traced, grouped, analyzed, and compared when further publications shall admit of determining the above mentioned principal branches.†

It appears, as stated by the Director, that all of the unreduced and unpublished results of the geologic and geographic survey of the Rocky Mountain region were transferred to this Survey, and likewise all of the similar material from the geologic and geographic survey of the Territories, except the natural history and a part of the paleontology.

Nothing whatever, either as to personnel, instruments, material, or supplies, professional or other records, published or unpublished maps and reports, or data of any sort, was transferred from the office of the United States Geographic Survey west of the 100th meridian, all the records of which were deposited in the archives of the Engineer Department, War Department, as heretofore stated.

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*At this writing (April 20, 1889) a number of topographic sheets—53 full degree (scale 1 to 250,000), 127 quarter-degree (1 to 125,000), and 101 one-sixteenth degree (1 to 62,500)—have been engraved and issued prior to the geologic work proper, but not for general distribution and use as topographic maps. Of the above, 53 full degree (about one-half from prior surveys), 70 quarter degree, and 2 of one-sixteenth degree are found west of the Mississippi (data furnished by Henry Gannett, in charge of Division of Geography, U. S. Geological Survey).

† No publication upon geographic co-ordinates has so far been mentioned in any of the "advertisement" prospectuses of the publications of this office, with the single exception of Bulletin No. 49, "On the latitudes and longitudes of certain points in Missouri, Kansas, and New Mexico, by R. S. Woodward," announced as in press March 1, 1889. (April 20, 1889.) Stated as published in Bulletin of July 1, 1889.

STATE DEPARTMENT.

UNITED STATES NORTHERN BOUNDARY COMMISSION.—LAKE OF THE WOODS TO THE SUMMIT OF THE ROCKY MOUNTAINS (49TH PARALLEL), 1872-'74.

The United States Boundary Commission, having for its object "to determine and mark the boundary line between the United States and British Possessions, as defined in the second article of the convention between the United States and Great Britain, of October 20, 1818," this line being the 49th parallel from the meridian of the northwest corner of the Lake of the Woods to the summit of the Rocky Mountains, was authorized by act of Congress, approved March 19, 1872, and commenced field operations at Pembina, September 1, 1872. Besides marking the boundary line, an accurate survey of all topographic features in a belt 5 miles wide on the United States side and of the shore of the Lake of the Woods from the 49th parallel to the mouth of Rainy River, was made and consolidated on a series of maps, as also reconnaissance surveys of all routes traveled by the geodetic and astronomic parties.*

The work of the Commission divides itself into astronomic and geodetic, which will be given separately.

First, Astronomic.—1872. In this year two astronomical stations were observed, thus determining the "northwest point" of the Lake of the Woods and the initial point or the west bank of the Red River of the North, Capt. W. J. Twining being the observer.

1873. Captain Twining observed at Pointe Michel, 20 miles west of Red River, at Turtle Mountain, west side, and at west of Rivière des Lacs, 237 miles west of Red River.

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* The United States Commission was organized with Archibald Campbell, Commissioner, and Maj. F. M. Farquhar, Corps of Engineers, chief astronomer; Capt. W. J. Twining, First Lieut. J. F. Gregory, and Second Lieut. F. V. Greene, Corps of Engineers, being detailed as assistants. In the spring of 1872, Major Farquhar having been relieved at his own request, Captain Twining was appointed and thereafter continued chief astronomer.

The 49th parallel was determined as follows: Astronomical stations were established alternately by the British and United States Commissions at approximate distances apart of 20 miles, and these were connected by tangents checked by azimuths at each end. The offsets to the parallel from these tangents were corrected proportionally, the astronomical determinations being considered absolute. The latitudes were determined by zenith telescope, the longitudes by chained distances from Red River (the initial point). These longitudes were to have been checked by telegraphic comparisons and determinations through Fort Shaw, Mont., to Corinne, Utah, which proved impossible because communication was broken during the period of operations. Iron monuments, one mile apart, were planted to mark the line from longitude 95° to 99° west, with usually stone pyramids in the more westerly portions.

Capt. J. F. Gregory observed at Pembina Mountains, east side, at Long River, at South Antler Creek, at Mouse River, at Mid Coteau, at Bully Spring, and at Four-hundred-and eight-and-a-half-mile Point.

Assistant Lewis Boss observed at Pembina Mountains, west side.

1874. Captain Gregory observed this year at Frenchman's Creek, Pool on Prairie, East Fork Milk River, Milk River Lakes, East Butte, Red River, North Fork Milk River, and at Chief Mountain Lake The line was completed from longitude 106° 12′ to the summit of the Rocky Mountains, where the survey connected with that part of the northwestern boundary heretofore established (1859).

In 1872 Capt. and Bvt. Lieut. Col. F. M. Farquhar, Capt. and Bvt. Maj. W. J. Twining, and Lieut. J. F. Gregory, all of the Corps of Engineers, were the astronomical observers.

The escort in 1872 was a part of Capt. A. A. Harbach's company, Twentieth Infantry; in 1873 two companies of the Seventh Cavalry and Captain Harbach's company, Twentieth Infantry, all under command of Maj. M. A. Reno, Seventh Cavalry; and in 1874 two companies of the Seventh Cavalry and five companies of the Sixth Infantry, under Major Reno.

The instruments used were zenith telescopes Nos. 7, 11, and 20, by Wurdemann; Nos. 7 and 11 were of 25 inches focal length, damaged by use; No. 20, of 32 inches focal length, in good condition. The chronometers, three in number, were by Negus, of New York, and Bond, of Boston. The sextants, two in number, were by Stackpole & Bro., New York. Astronomical transits in 1873, No. 30, and in 1874, No. 4; both by Wurdemann.

Second, Geodetic.—Lieut. F. V. Greene was placed in charge of the tracing of the line and of the topographic work in the years 1872, 1873, 1874, and 1875. The methods of work in these branches will be found described by Lieutenant Greene (pp. 341–369), Appendix B, of the main report, which is published as Senate Ex. Doc. No. 41, Forty-fourth Congress, second session, and contains reports of the Commissioner, Archibald Campbell; of Captain Twining, Captain Gregory, Lieutenant Greene; and the maps, except the preliminary and final series.

The original plats of this survey were transferred to the archives of the Engineer Department.

Capt. J. F. Gregory, U. S. Engineers, in connection with the Northern Boundary Survey during the first field season of 1872, was in charge of the geodetic and topographic work with Lieut. F. V. Greene and Mr. F. Von Schrader (now Lieutenant, Twelfth Infantry), as assistants. Work this season was confined to topographic surveys in vicinity of the boundary line, the Red and Pembina Rivers, the establishment of the northwest angle of the Lake of the Woods, and surveys in that vicinity of the boundary.

In 1873 he was in charge of an astronomical party with Mr. E. L. Mack and Mr. O. S. Wilson as assistants.

Observations for latitude were made at seven stations and the parallels marked with large stone mounds. A part of the sextant work was done by Mr. Wilson.

Reconnaissance was made from the second crossing of the boundary line (in longitude 102° approximate) to Fort Totten, Dakota, and thence to Fort Seward, crossing Mouse River at the mouth of Willow Creek.

Lieut. (now Captain) C. O. Bradley, Twentieth Infantry, commanded the escort, beginning with fourteen enlisted men, afterwards increased to twenty-six in number.

1874. Had charge of an astronomical party with Mr. Lewis Boss and A. J. Egerton as assistants. Dr. Elliott Coues, surgeon U. S. Army, accompanied the party as naturalist.

Eight astronomical stations along the 49th parallel were determined and marked, carrying the work to its western limit on Chief Mountain Lake, of the Pacific water-shed.

Reconnaissance surveys of the trails were made by compass and odometer. Also observed for latitude of Fort Buford with zenith telescope, and made reconnaissance from the mouth of Polar River to west bank of Frenchman's Creek, and to the boundary line about longitude 107° 24′.

Observations for time and latitude en route were made by Mr. Boss. Longitudes and latitudes were determined by sextant and chronometer of the trail, from Station Thirteen to Fort Buford.

Mr. Boss made a reconnaissance of the route from the termination of the boundary to Fort Benton.

The escort consisted of Company D, Sixth Infantry, about forty men and three Indian scouts, commanded by Capt. M. Byrant, Sixth Infantry (now Major, Fourteenth Infantry), and Lieut. F. W. Thibaut, Sixth Infantry, second in command.

1875. Set the cast-iron pillars* east and west of Red River, at even mile intervals, and made special surveys at the northwest angle, Lake of the Woods.

The escort consisted of twelve enlisted men commanded by Lieut. C. H. Low, Twentieth Infantry. The last astronomical station was established on Chief Mountain Lake, a special geodetic and topographic survey of which and the neighboring mountain region was made by Assistant Boss.

RECONNAISSANCES AND SURVEYS BY LIEUT. F. V GREENE, CORPS OF ENGINEERS, IN CONNECTION WITH THE UNITED STATES NORTHERN BOUNDARY COMMISSION (1872–'73).

Lieutenant Greene, acting under general instructions from Major Farquhar, United States Engineers, in 1872, and subsequently from Captain Twining, United States Engineers, chief astronomer Northern Boundary Commission, commenced September 5, 1872, at latitude 49° on Red River.

The field work intrusted to him comprised the immediate charge and direction of the parties engaged upon geodetic and topographic operations, and the making of reconnaissance surveys of all routes passed over by these parties, outside of the belt of more accurate surveys. It was accomplished within the following dates:

1872. September 5 to November 12. From Red River eastward to Roseau River, 33 miles. Topographic survey by theodolite and chain of Red River near the boundary. Escort, Company K, Twentieth Infantry, Capt. A. A. Harback; civil assistant, F. Von Schrader.

1873. June 8 to October 25. From Red River westward to Poplar River, 384 miles. Assistants: Computer, L. Chauvenet; topographers, F.

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* These pillars were "hollow iron castings, three-eighths of an inch in thickness, in the form of a truncated pyramid, 8 feet high, 8 inches square at bottom, 4 inches square at top with solid pyramidal cap, and an octagonal flange, one inch in thickness at bottom," with an average weight of 85 pounds. A list of all the monuments, some few of which were stone pillars and cairns and earth-mounds, are given on pp. 35–40 of the report.

Von Schrader, A. Downing, C. L. Doolittle. The escort, from September 11 to October 15, was a detachment of twenty-five cavalry under command of Lieut. R. H. L. Alexander.

1873–'74. October 25 to February 16. From Red River to Lake of the Woods, 88 miles; thence to Rainy River. No escort. Assistants: Computer, O. S. Wilson, C. E.; topographers, C. L. Doolittle, A. Downing.

1874. June 21 to October 1. From Poplar River to the summit of the Rocky Mountains, 380 miles. Escort, two companies Sixth Infantry and twelve Indian scouts, Capt. E. R. Ames, Sixth Infantry, in command. Assistants: Computer, O. S. Wilson, C. E., topographers, C. L. Doolittle, V. T. McGillicuddy, B. Vitzthum.

In 1873–'74 the escorts were parts of a general escort under command of Maj. M. A. Reno, Seventh Cavalry.

1874. First, a reconnaissance from Frenchman's Creek on the Missouri, in longitude 104° 54′ along Poplar River and its branches to the 49th parallel, made as above, with three astronomic camps. Second, a reconnaissance from astronomical station 24 to astronomic station 25 by way of Fort Turney on Frenchman's Creek; one astronomic camp. Third, a reconnaissance of the trail made by the wagon train while Lieutenant Greene was running the meridian line to Fort Shaw; two latitude camps. Fourth, a reconnaissance along the "Riplinger Road," skirting the base of the Rocky Mountains from the 49th parallel to Fort Shaw, by C. L. Doolittle; four latitude camps. Fifth, a reconnaissance from Fort Shaw to Fort Benton; one astronomic camp. Sixth, boat survey of the Missouri River from Fort Benton to Bismarck, September 10 to October 1. This was based on the astronomic determination of 17 points on the river, by sextant for latitude and time, and by the mean of six chronometers, compared daily, and with well deduced traveling rates for longitude—the longitude of Fort Benton being determined by chronometers transported from the boundary, and that of Bismarck by telegraph by Major Barlow. Between these points courses were kept with 6-inch vernier compasses by Doolittle and McGillicuddy, and distances estimated by time and the speed of the current. In reducing the computed co-ordinates, compass notes were adjusted to the astronomic observations.

1875. July 1 to September 13. Lieutenant Greene proceeded to Fort Shaw, connected the meridian line with the flagstaff and with the principal meridian of the land office, but was unable to obtain a telegraphic longitude of the fort.

The topographical information gained by these surveys was compiled under the supervision of Captain Twining into the following maps:

(1) A preliminary series in an index and forty-five sheets, on a scale of 1 inch to 1 mile,[*] which show the topography of the 5-mile belt. These were photolithographed at once upon completion, and furnished the British Commission.

(2) A final series of joint maps in an index and twenty-four sheets, on a scale of 1 inch to 2 miles, which take in the topography for 4 miles on the British side of the line, and have been reduced from the British and United States preliminary series. Of these final sheets twelve were executed by the British Commission and twelve by the United States. In both series the polyconic projection was used.

Draughtsmen employed: A. A. Aquirre, E. Mahlo, E. Collet, A. Von Hoake, and A. Downing.

In addition to the above the following reconnaissances were made by Lieutenant Greene:

1873. October 15–25. From the second crossing of Mouse River (latitude 49° longitude 101° 54′ 58″), along Mouse River on its southern bend to near the mouth of Wintering River; thence direct to Fort Totten. Trail was kept by C. L. Doolittle with vernier compass, odometer, and flags. Seven camps were located astronomically by sextant; latitudes and longitudes by two Negus box chronometers, with traveling rates well deduced from observations at Mouse River crossing and at Pembina, both well established points.

The notes of these reconnaissances were compiled into a series of "reconnaissance maps," a profile and six maps, on a scale of 1 inch to 8 miles, which show the general features of the country from latitude 47° 30′ to 49°, and from longitude 94° 30′ to 114° 05′ (projection polyconic).

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[*] The topographic field plots were reduced on scale of 1 to 20,000, at once, or immediately upon reaching the office.

The positions of the following military posts were determined: Fort Pembina, Dak., latitude 48° 56′ 45″.1, longitude 97° 13′ 47″.4; Fort Buford, Dak., latitude 47° 59′ 22″.19, longitude 103° 58′ 20″; Fort Totten, Dak., latitude 47° 58′ 40″, longitude 99° 01′ 38″; Fort Shaw, Mont., latitude 47° 30′ 33″.2, longitude 111° 45′ 19″.5; Fort Stevenson, Dak., latitude 47° 34′ 20″, longitude 101° 26′ 40″.

Lieutenant Greene, though always with detached and independent parties, acted subsequent to 1872 under general instructions from Captain Twining, chief astronomer of the Commission.

The British Commission consisted of Capt. D. R. Cameron, R. A., Commissioner, and Capt. S. Anderson, R. E., chief astronomer.

The Commissions worked in harmony throughout, establishing jointly the initial and other necessary points, and agreeing upon the boundary as the astronomical rather than the mean parallel of latitude 49° north.

Dr. Elliott Coues, surgeon, U. S. Army, accompanied the Commission as surgeon and naturalist, making field observations and collections, which latter was also done to the extent that circumstances would permit.

The results of the observed and computed latitudes of principal stations are found on pages 96 to 169; those for astronomical stations, with probable errors, are tabulated on page 95, and a list of latitudes and longitudes with altitudes added, on pages 198–199, with British latitudes on page 198; longitudes, pages 349 to 355, and on page 298 a summary of results with probable errors.

TREASURY DEPARTMENT.

COAST AND GEODETIC SURVEY.

Prior to the commencement of operations by the Coast Survey on the Pacific, only two nations (Spain and Russia) had had anything like a permanent establishment for the exploration of the west coast.

It might be said that the English had a principal center of exploration founded in 1824 at Fort Vancouver, from which many exploring expeditions, by sea and land, were sent out.

Instructions for the extension of the Coast Survey to the Pacific were issued by the Treasury Department in 1848, when the work, then consisting of a general reconnaissance of the whole coast, was placed under the charge of Lieutenant MacArthur, of the Navy.

Since the above date the field and office work has gradually developed through the necessary preliminary and formative stages, culminating in a hydrographic and topographic survey of the regular standard order of value of this work, done on the eastern coast, which, for our possessions from the Mexican boundary to Fuca Straits with Puget's Sound, was, at the close of the season of 1884, about three-fifths done, and the publication of charts, sailing directions, and tide tables proportionately advanced.

Nothing less than an inspection of the several Annual Reports since 1849 will give anything like an adequate view of the work.

The following table, kindly furnished from the office of the Coast Survey, relates to the results for the eastern gulf and west coasts:

U. S. Coast and Geodetic Survey.—Astronomical, Geodetic, and Magnetic Statistics.

Operations and Items—Results.	Total to July, 1885.
Reconnaissance (both exterior and interior):	
Area in square statute miles	377,960
Base lines:	
Primary, number of, measured and computed	14
Primary, length of, in statute miles	90
Subordinate, number of, measured and computed	130
Subordinate and beach measures, length of	476
Triangulation:	
Area in square statute miles (exterior and interior)	190,864
No. of stations occupied for horizontal measures	11,060
No. of (observed computed) geographical positions determined	21,105
No. of stations occupied for vertical measures	702
No. of elevations determined trigonometrically	1,915
No. of heights of bench-marks by spirit leveling	3,014
Lines of spirit leveling, length of, in statute miles	3,330
Astronomical work:	
No. of azimuth stations	190
No. of latitude stations	318
No. of longitude stations, telegraphic	127
No. of longitude stations, chronometric or lunar	110
Magnetic work:	
No. of stations occupied	693

NOTE.—The above statistics are necessarily approximated; at the time they are prepared the field records may not be all in; the triangulation sketches are not ready for use, and the computations not made to allow of accurate counting.

It was found impossible to separate the numbers for the Atlantic, the Gulf, and the Pacific coasts and Alaska.

No separation could be made between the primary, secondary, and tertiary triangulation, since they shade into each other by degrees, and interlace interminably. No area is counted twice, nor any station, though re-surveys may have been made.

Late information from the office of this Survey indicates that "more than 5,500" of the above are "geodetic positions;" to none of the latter, however, can any final value be assigned at present for the very obvious reason, viz, the incompleteness of the primary or main triangulation designed to connect them. These positions are therefore neither on uniform data, nor as yet properly supported, and consequently the time for their publication has not arrived.

Instruments.—The following are among the principal field instruments now being used by this office:

Reconnaissance: Gradientas, sextants, prismatic compasses, and tape lines.

Geodesy: Primary 6-meter compensating base apparatuses, 4-meter secondary base apparatuses, 16 and 8 inch theodolites, reconnoitering telescopes, heliotropes, gradienters, and signal lamps for night observations.

Astronomy: (1) Zenith telescopes for latitude; (2) 46-inch transits, adapted for time and latitude; (3) prismatic transits for time and latitude; (4) electric chronographs for registering time observations; (5) telegraphic key-boards; (6) personal-equation apparatuses.

Topography: Plane tables complete, with a telemeter rod.

Hydrography: Sextants, optical densimeters, deep-sea thermometers, and self-registering tide-gauges.

Miscellaneous: Pendulums, geodesic levels, tide-predicting machines, maximum and minimum thermometers, and a stoppered level.*

Mr. F. H. Hassler was Superintendent from 1807 to 1818, and from 1832 to 1843; Prof. A. D. Bache from 1843 to 1867; Prof. Benj. Peirce from 1867 to 1874; Carlile P. Patterson from 1874 to 1881; Julius E. Hilgard till 1885; and at present Mr. F. M. Thorn.

According to a statement of the Superintendent, of March 11, 1884, there were 63 field and 114 office civilian assistants, while in August, 1884, there were 58 naval officers and 340 seamen of the Navy engaged. The total number of the field parties (1884–'85) is given as fifty-eight. The total personnel (civilians, naval officers, and seamen) aggregated 575 in all.

The salaries and allowances to the normal force, with names, will be found on page 764 *et seq.* Senate Mis. Doc. No. 82, Forty-ninth Congress, first session.

Army officers were employed on this work up to the war of the rebellion, since which date none have been so employed.

The objects of the Coast and Geodetic Survey will be found on page 525 *et seq.* House Ex. Doc. No. 270, Forty-eighth Congress, second session, under the head of "Functions," which show that its practical results in the main are as an aid to navigation and commerce, while the classes of work prosecuted may be said to be generally astronomic, base measuring, trigonometric, topographic, hydrographic, tidal, magnetic, deep-sea soundings, and sea-current observations, in the field, and their subsequent office reductions, with publication in a series of annual reports and charts.

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* Short descriptions of these instruments are given in a pamphlet at the exhibit of the Survey at New Orleans, 1884–'85, and are referred to in Appendix No. 18, Coast Survey Report, 1884.

The field work of the Survey is divided in twelve sections for the coast proper, to which four others have been added for transcontinental work and the aid rendered State surveys.

The work as a whole has been mainly hydrographic, the topography usually extending inland from 1 to 3 miles from the shore line, of which Nos. IX, X, XI, XII, XV, and XVI, are the divisions prosecuting field work west of the Mississippi River. (See Annual Report, 1885.)

At the end of 1885 the topography had embraced an area of 3,364 square miles.[*]

Likewise the inside hydrography had embraced 3,500 square miles, and the outside hydrography 5,740 square miles.[†]

Until within a few years the explorations in Alaska were carried on without system, scattered along the whole coast.

In 1883 regular reconnaissance work, comprising topography and hydrography preliminary in character, was begun, and had progressed (end of 1885) over an area of 3,500 square miles.

Off-shore and deep-sea soundings (including Commander Belknap's soundings in the *Tuscarora*) have been made in the Santa Barbara channel, and in the approaches to San Francisco, over an area of about 4,250 square miles.

The transcontinental triangulation in vicinity of 39th parallel was reported at end of 1885 as about three-fifths done, the gaps west of the Mississippi being between Kansas City, Mo., and Mount Carson, Colo., about 8° longitude (450 miles), and between Pike's Peak, Colorado, and

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[*] As a rule the topography extends 1 to 3 miles from the shore line; in special cases much further, in others less.

[†] The inside hydrography comprises the general coast line, and includes all bays, sounds, and rivers. The outside hydrography comprises the close surveys outside the coast line, including open bays, averaging 15 miles in width, with ranges from 5 to 30 miles.

Salt Lake City, Utah, about 70° longitude (375 miles). Levels of precision have only extended a few miles west of St. Louis.

Tidal observations were commenced by the Coast Survey about 1834, and have been made at over one thousand stations, mainly on our own coasts.

They are usually prosecuted primarily for hydrographic purposes while some are series recorded by self-registering tide-guages, with a view to tidal predictions, tidal tables based on which are issued annually.

Of the latter there are now six of nineteen years or more, and twenty-nine ranging from one to nineteen years.

The tidal tables of 1887 contain the predicted times and heights of high and low waters for every day in the year, at four principal and ninety-two subordinate (or derivative) stations on the Pacific coast.

Gravity determinations are reported at San Francisco, and magnetic observations and compilations have always been undertaken in conjunction with the regular work, the latter made general for the whole United States.

Longitudes, as determined by the electric telegraph between 1846 and 1885, appear as Appendix No. 11, Annual Report, 1884.

Certain late longitudes, latitudes, azimuths appear as Appendix No. 9, Annual Report, 1885, and heights of stations in Appendix No. 10, Annual Report, 1884.

Lists of geographical positions may be found in the following Coast Survey Annual Reports: Appendix 12, 1851, pp. 162–442; Appendix 7, 1853, pp. 14–42; Appendix 8, 1855, pp. 119–148; Appendix 25, 1857, pp. 264–301; Appendix 20, 1859, pp. 216–267; Appendix 15, 1864, pp. 144–182; Appendix 9, 1865, pp. 99–136; Appendix 10, 1865, pp. 137; Appendix 13, 1868, pp. 171–242; Appendix 6, 1874, pp. 62–65; Appendix 11, 1874, p. 134, and Appendix 8, 1885, pp. 285–439, including points established by the Borden Survey of Massachusetts. A list of heights of trigonometric stations appears in Appendix 9, 1870, pp. 90–91. A description of bench-marks at tidal stations is found as Appendix 10, 1870, pp. 92–97.

An exploration and discussion of the field and office methods now in vogue in this work, together with the construction of maps, will mainly be found in the following Annual Reports:

Bases.—Appendix 11, 1883, pp. 277–288, and Appendix 8, 1882, pp. 139–149.

Triangulation.—Appendix 17, 1875, pp. 279–292; Appendix 20, 1876, pp. 391–399; Appendix 9, 1882, pp. 151–197, and Appendix 9, 1885, pp. 441–467.

Latitude.—Appendix 10, 1866, pp. 72–85.

Longitude —Appendix 6, 1880, pp. 81–92.

Time, longitude, latitude, and azimuth —Appendix 14, 1880, pp. 201–286; Appendix 7, Annual Report, 1884, pp. 323–375.

Geodesic leveling.—Appendix 11, 1882, pp. 517–556.

Plane tables.—Appendix 13, 1880, pp. 172–200.

Ellipticity.—Appendix 15, 1881, pp. 442–456.

Magnetic div and intensity.—Appendix 6, Annual Report, 1885, pp. 129–274.

Topographic and hydrographic delineation.—Appendix 20, 1860, pp. 216–229.

Projections.—Appendix 15, 1880, pp. 287–296, and Appendix 6, 1884, pp. 135–321.

Topographic drawings.—Appendix 14, 1883, pp. 367–368.

Computations, formula, and factor.—Appendix 7, 1884, pp. 323–375, and index to scientific papers; Appendix 6, 1881, pp. 91–123.

The publications of the Coast Survey consist of "Annual Reports," "Charts," "Coast Pilots," "Tide-Tables," and professional and scientific papers, the latter usually appearing as appendixes to the "Annual Reports."*

The latter have appeared from 1853 to date, in quarto form; prior to which they formed a part of the regular executive document series.

The charts are classed as "finished" and "preliminary." The former are printed from engraved plates, and include all details; the latter are issued as soon as possible after the survey to meet the most pressing needs of navigation, and are either engraved or photolithographed.

The general character of the charts is as follows:

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*A general index of scientific papers, methods, and results, found in the appendixes to the several Annual Reports, appears as Appendix 6, Annual Report, 1881, and a descriptive catalogue of publications forms Appendix 6, Annual Report, 1883.

1. Sailing charts, scale 1 to 1,200,000, exhibiting the approaches to a large extent of coast, and giving offshore soundings.

2. General charts of the coast, scales 1 to 400,000 and 1 to 200,000, especially intended for coastwise navigation, showing configuration of the shore, the positions of islands, rocks, and shoals, the light-houses, life-saving stations, and other natural and artificial landmarks.

3. Coast charts, scale 1 to 80,000, from which may be recognized the beacons, buoys, light-houses, etc., while entering channels to bays and harbors.

4. Harbor charts, in large scales for needs of local navigation. The total number of charts of all kinds issued, as shown by official catalogue of 1886, is 402, distributed as follows:

Locality.	Engraved.		Photo-lithographed.	Total.
	Finished.	Preliminary.	Preliminary.	
Atlantic and Gulf coasts	209	19	59	287
Pacific coast	26	24	22	72
Alaska	....	....	43	43
Total	235	43	124	402

Thirty-eight miscellaneous maps and plans, not adapted for the use of navigators, have also been issued. (See catalogue.)

A compilation for a general map of the United States (scale 1 inch to 10 miles) was begun in 1883 and continued while a small appropriation was available. (See Appendix 4, Annual Report, 1883.)

An elaborate model, in plaster, of the Atlantic Basin and Gulf of Mexico, has been constructed.

UNITED STATES NAVAL OBSERVATORY.

When practicable this office has co-operated with survey parties in the West, and has also established independent astronomic latitudes and longitudes, to be found mentioned in the following volumes, published by the Naval Observatory:

Washington astronomical and meteorological observations, Vol. XIV, 1869, Appendix II, report of Professor Newcomb, U. S. Navy, page 13.

Vol. XIV, 1869, Appendix II, report of Prof. William Harkness, U. S. Navy, page 40.

Vol. XIV, 1869, Appendix II, report of Prof. William Harkness, U. S. Navy, page 49.

Vol. XIV, 1869, Appendix II, report of Prof. William Harkness, U. S. Navy, page 59.

Vol. XVII, 1870, Appendix I, page 39.

Vol. XIX, 1872, Appendix II, pages 15, 19, and 21.

Vol. XXI, 1874, Appendix II, page 10.

Vol. XXIII, 1876, Part II, Appendix III, pages 43, 48, 116, 138, 139, 175, 186, 253, 334, 348, and 408.

Vol. XXIV, 1877, Appendix V, page 15.

It has been ascertained that the Nautical Almanac Office published a special report by Prof. A. C. Coffin, U. S. Navy, in 1869 (pp. 69–71), upon the total solar eclipse, containing independent determinations of astronomic latitudes and longitudes west of the Mississippi.

MISCELLANEOUS.

Survey operations, including one or more of triangulation, topographic, geologic, or cartographic factors, have been conducted by several States, but it is not the province of this memoir to indicate their scope or results.* As to the latter, the geographic co-ordinates of but few points have been determined. Of all railroad surveys that one projected and partially completed by the Northern Pacific has been the most comprehensive and refined. The progress and results of all works of survey not prosecuted directly by the General Government should be currently secured and availed of at a permanent bureau, as herein mentioned.

MAPS.

Although the present volume has not been printed until 1889, yet circumstances have prevented the continuation in detail of the works and results of the several expeditions and surveys west of the Mississippi River since 1880, yet it has been possible to add a reference to the existing topo-

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*A brief reference to State surveys then existing between 1875 and 1881, will be found on page 59 *et seq.* House Ex. Doc. No. 270, Forty-eighth Congress, second session.

graphic maps of a general character, the outgrowth of the several offices and organizations, that have contributed each its quota to our general knowledge of the topography and geography of the interior of our country. The following list is believed to be complete at date of its compilation (March 31, 1887):

MISCELLANEOUS, TOPOGRAPHIC, AND OTHER GOVERNMENT MAPS, INCLUDING GEOLOGIC.

UNITED STATES.

Description or name of map.	Scale.	No. of sheets when complete.	Total issued.	By whom issued.	Administration.	Remarks.
Outline map of the United States.	[illegible]	4	4	Engineer Department, U. S. Army.	War Department.	Prepared in the Office of the Chief of Engineers, U. S. Army, 1885. Military posts shown by colored flags.
Outline map of the United States, showing location of works and surveys for river and harbor improvements.	[illegible]	4	4	....do	....do	Compiled for the index to Report of Chief of Engineers, 1879. Printed in black.
Land Office map of the United States.	[illegible]	4	4	General Land Office.	Interior Department.	Compiled and printed in black and five colors, 1884. A new map of the United States has been compiled on same scale (1 inch to 40 miles), and issued in 4 sheets.
Topographical Atlas of territory of the United States west of the 100th meridian.*	[illegible] [illegible]	 95	35 15	Office of Geographical Surveys under Engineer Department.	War Department.	Thirty sheets issued with land classification. Topography based on initial astronomic points and trigonometric net. Natural objects, means of communication, artificial and economic features prominent according to importance. Geology and natural history incidental to main purpose, *i. e.*, Topography.
Geological Atlas of territory of the United States west of the 100th meridian.	[illegible]	95	11	....do	....do	Colors superposed directly upon topographic sheets of same scale.
Atlas of geological exploration of 40th parallel (special topographic sheets).	[illegible]	5	5	Engineer Department, U. S. Army.	....do	Topography from a geological standpoint, *i. e.*, natural features prominent, communications less so, in artificial and economic details deficient. Outlines engraved, hill work in crayon, shading based on partial contours.
Atlas of geological exploration of 40th parallel (special geological sheets).	[illegible]	5	5	....do	....do	Outlines engraved. Elevations in contours. Geological formations in colors, superposed on the topographic map as a base. Also 1 sheet of geologic sections and an index map, 1 inch to 6 miles.
Outline map of territory of the United States west of the Mississippi River.	[illegible]	4	4	....do	....do	Prepared in the Office of the Chief of Engineers, U. S. Army. Printed in black; printed also in hachures in color.

MISCELLANEOUS, TOPOGRAPHIC, AND OTHER GOVERNMENT MAPS, ETC.—Continued.

UNITED STATES—Continued.

Description or name of map.	Scale.	No. of sheets when complete.	Total issued.	By whom issued.	Administration.	Remarks.
Part of atlas of Colorado.	[illegible]	6	6	Geological Survey of the Territories.	Interior Department.	Topography from a geological standpoint. Natural features most prominent, communications less so, artificial features still less.
Part of geological atlas of Colorado.	[illegible]	6	6	....do	....do	Result of color directly superposed upon topographic map of same scale. This atlas also contains 4 sheets, each scale 1 inch to 12 miles, embracing the State, showing triangulation, drainage, land classification, and general geology; also geologic sections and panoramic views.
Charts of the survey of northern and northwestern lakes.	[illegible]	79	79	Engineer Department, U. S. Army.	War Department.	Work begun 1841; completed 1881. Re-edition of 69 charts being issued, printed in black. Elevations on older charts in hachures; on others by contours, 20 feet and 60 feet intervals, and hachures. Copper engraved; preliminary edition of 24 sheets by photo-lithography. For use of lake vessels and as an aid to river and harbor improvements.
Survey of part of Mississippi River.	[illegible]	229	16	Mississippi River Commission.	....do	Photo-lithographed. Printed in black; elevation by contours at 3 feet and 5 feet intervals. From Cairo to Wolf Island and Memphis to Commerce Cut-off, from field data by Lake Survey (Comstock), the balance in MS. only and not to be published; 50 in outline; 137 with full topography, which with 16 published embrace the river from Cairo to Donaldsonville, below which are charts by Coast Survey; also 26 lake charts (5 feet contours).
Do.	[illegible]	69	9	....do	......	Reduction from [illegible] by photolithography combining several sheets in one.
Maps of part of Mississippi River.	[illegible]	32	32	....do	....do	These include the river from Cairo to the head of the Passes; also 2 index charts and 2 of titles and notes, surveys by Mississippi River Commission.
Alluvial Valley of the Mississippi.	[illegible]	8		....do	....do	Shows area overflowed, existing levees, cross sections, etc., compiled from all existing surveys from Cape Girardeau to the Gulf, including the several subdivisions of the lower river.

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* For publications issued by this work, see "List of Reports and Maps of the United States Geographical Surveys west of the 100th Meridian," 3d edition, 1881; also, Annual Reports, Chief of Engineers, 1873 to 1888.

The General Land Office of the Interior Department issues compiled planimetric maps of the United States, as also of the States and Territories wherein remain unsold public lands, in black and two colors, except for Florida and Arizona, which are in three colors. Ohio and Indiana, scale 1 inch to 10 miles; Alabama, Arkansas, Florida, Iowa, Mississippi, Wisconsin, Indian Territory, and Dakota, scale 1 inch to 12 miles; Illinois, Louisiana, and Missouri, scale 1 inch to 14 miles; Colorado, Kansas, Minnesota, Nebraska, Oregon, Arizona, Utah, Washington Territory, and Wyoming, scale 1 inch to 15 miles; Michigan, Nevada, Idaho. and New Mexico, scale 1 inch to 16 miles; and California and Montana, scale 1 inch to 18 miles.

The Post-Office Department has, since the year 1869, issued twenty-five separately compiled planimetric maps, aggregating sixty-three sheets, each embracing a single or a number of States, on scales of 1 inch to 6 miles for the largest, and 1 inch to 15 miles for the smallest (issued bi-monthly).

The Coast Survey commenced the compilation of a general map of the United States, scale 1 inch to 10 miles (engraving and publishing the plate showing New Jersey and adjoining territory), the appropriation for which, however, is now suspended.

Of the regular hydrographic charts of the Coast Survey, 402 have been issued, on forty-seven different scales, from 1 : 3000 to 1 : 3500000. (See catalogue, 1886.)

Certain preliminary maps and those prepared to accompany reports were issued by the geological exploration of the Colorado River, and the geological and geographical survey of the Rocky Mountain region under J. W. Powell.

The geological explorations of the Black Hills published one topographic and one geological map of the Black Hills, each scale 1 inch to 4 miles. The relief of the topographic sheet is by contours and hachures, with drainage in blue; that for geologic purposes with contours and drainage in black.

The present Geological Survey has also issued three sheets embracing territory in northeastern Arizona and northwestern New Mexico; and there have also been printed by this office fifty-three sheets, scale 1 inch to 4 miles, for areas west of the Mississippi River, each representing one degree of latitude and one of longitude (about one-half from prior surveys) as a topographic base for field purposes and upon which to delineate and subsequently publish, in colors, the geological formations. Also seventy quarter degree and two one-sixteenth degree sheets.

Various compiled maps, especially of western areas, prepared at the Engineer Office, headquarters military divisions and departments, have been published, when possible, as currently required. (See Annual Reports, Corps of Engineers, to date.)

Material now exists from which the compilation of a general military topographic atlas of the United States,* including Alaska, could be begun, resulting from various works, and found distributed among the following Government offices:

WAR DEPARTMENT.

In the Engineer Department are lodged original and other results from the following: (1) United States Lake Survey (northern lakes and part of

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* See also essay by Lieut. M. M. Macomb on "The necessity for a fixed policy in the War Department in regard to * * * the construction of a general military atlas of the United States."

St. Lawrence River); (2) United States geographical surveys; (3) geological exploration of the 40th parallel; (4) river and harbor surveys; (5) fortification surveys (in manuscript only); (6) Pacific Railroad surveys; (7) bureau of exploration and surveys, including military and geographical surveys west of the Mississippi; (8) exploration and reconnaissance headquarters of military divisions and departments, including surveys of military reservations; (9) certain international boundary surveys; (10) exploration of Yukon River, Alaska.

In the War Department proper may be found explorations in Alaska (Allen), and notes, maps, etc., at the various engineers' offices, headquarters divisions and departments.

The Mississippi and Missouri River Commissions retain in their offices manuscript material of special topographic and hydrographic surveys made under their auspices.

TREASURY DEPARTMENT.

Office of the Coast and Geodetic Survey for topography of the Atlantic, Gulf, and Pacific coasts; also Alaska, transcontinental triangulation, and that in aid of State surveys, including Mississippi River to head of tidal influence and precise levelings.

INTERIOR DEPARTMENT.

The General Land Office for its subdivision plats; boundaries between States and Territories; surveys of private land claims and Indian reservations; topography of the United States geological survey of the Territories; the geological and geographical survey of the Rocky Mountain region; the geological exploration of the Black Hills, and the United States geological survey.

STATE DEPARTMENT.

Records of the Texas, Northeast, Northwest. Northern and Mexican boundaries.

NAVY DEPARTMENT.

Latitudes and longitudes by the Naval Observatory and Nautical Almanac.

There are also results from all State boundaries; the subdivision surveys in Texas; triangulation and topography by the State surveys of Massachusetts and New York; topography of State geologic surveys of New Hampshire, New York, New Jersey, Pennsylvania, Ohio, North Carolina, Georgia, Michigan, Missouri, and California; of surveys for railroads, including transcontinental survey, and canals, for turnpike, toll, and other wagon-roads, for counties, towns; also, by private or corporate parties, including the utilization of all manuscript and published data from all of these surveys, decided as available after competent inspection.

Systematic compilation, based upon the above, should be constantly prosecuted independently of whatever field-work may be carried forward.

Imperfect as it is feared the foregoing memoir may prove, resulting in part from want of assistance and ill health during its preparation, one trusts that it will serve to perpetuate in authentic form an official record of those organizations, officers, and others that as a whole have contributed to the aggregate of our present critical geographic knowledge of that portion of our territory west of the Mississippi up to 1880.*

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* There does not yet exist a published list of the principal latitudes and longitudes established by the several Government surveys, gathered in a single tabulated view, and all known separately-published lists are in a measure fragmentary. Such a list, compiled under competent jurisdiction, accurately weighted as to precision, and classified, with description of monuments, and careful bibliographical references, although a matter of no little labor, would nevertheless prove of great permanent value.

APPENDIX G.

SYNOPTICAL TABLE OF CONTENTS OF QUARTO REPORTS, IN EIGHT VOLUMES, INCLUDING VOL. III, GEOLOGY. (SUPPLEMENT.)

VOLUME I.—GEOGRAPHICAL REPORT.

Capt. George M. Wheeler, Corps of Engineers, U. S. Army.

(See table of contents herewith, p. 3.)

VOLUME II.—ASTRONOMY AND BAROMETRIC HYPSOMETRY.

Introductory letter, Lieutenant Wheeler.

PART I. Astronomical co-ordinates, Ogden, Utah, pp. 7-55; Beaver, Utah, pp. 59-71; Pioche, Nev., pp. 75-96; Gunnison, Utah, pp. 97-125; Green River, Wyo., pp. 129-154; Winnemucca, Nev., pp. 157-182; Virginia City, Nev., pp. 185-210; Georgetown, Colo., pp. 213-237; Hughes, Colo., pp. 241-263; Labran, Colo., pp. 267-286; Trinidad, Colo., pp. 291-312; Fort Union, N. Mex., pp. 315-335; Santa Fe, N. Mex., pp. 339-369; Bozeman, Mont., pp. 373-384; Las Vegas, N. Mex., pp. 387-410; Cimarron, N. Mex., pp. 405-415; Sidney Barracks, Nebr., pp. 419-432; Julesburg, Colo., pp. 435-448; North Platte, Nebr., pp. 451-458; Dr. F. Kampf; Prof. T. H. Safford; J. H. Clark; W. W. Maryatt; E. P. Austin. Descriptive report of Salt Lake Observatory, J. H. Clark, pp. 451-467. Descriptive report of Ogden Observatory, Lieutenant Wheeler, pp. 469-471. Personal equation apparatus, Dr. F. Kampf, pp. 475-483. Descriptive list of astronomical stations, Lieutenant Wheeler, pp. 485-491.

II. Lieutenant Marshall, Corps of Engineers: Barometric hypsometry, pp. 497-529; tables, hourly observations, pp. 530-550; horary corrections, pp. 551-554; tables of altitudes, pp. 556-566.

VOLUME III.—GEOLOGY.

Introductory letter, Lieutenant Wheeler.

PART I. G. K. Gilbert; Nevada, Utah, California, and Arizona, 1871 and 1872, pp. 21-187.
II. A. R. Marvine; St. George, Utah, and Gila River, Arizona, 1871, pp. 189-225.
III. E. E. Howell; Utah, Nevada, Arizona, and New Mexico, 1872 and 1873, pp. 227-301.
IV. J. J. Stevenson; Colorado, 1873, pp. 305-501.
V. G. K. Gilbert; New Mexico and Arizona, pp. 503-567.
IV. Mineralogical and agricultural conditions, Colorado, New Mexico, and Arizona, 1873; O. Loew, pp. 569-661.

VOLUME III (SUPPLEMENT).—GEOLOGY.

Letter of transmittal, Captain Wheeler.

PART I.—*Prof. J. J. Stevenson, Ph. D.*

Introduction.
CHAPTER I. General physical features, pp. 13-27.
II. Notes respecting previous explorations, pp. 28-36.

PART II.—*Systematic Geology, Professor Stevenson.*

CHAPTER III. Displacements of the strata, pp. 37–65.
IV. The Archæn Rocks, pp. 66–72.
V. The Carboniferous Rocks, pp. 73–84.
VI. The Jura Trias, pp. 85–87.
VII. The Dakota Group, pp. 88–94.
VIII. The Colorado Group, pp. 95–101.
IX. The Laramie Group, pp. 102–130.
X. The relations of the Laramie, pp. 131–158.
XI. The Tertiary Rocks, pp. 159–174.
XII. Surface geology, pp. 175–192.

PART III.—*Descriptive Geology, Professor Stevenson.*

CHAPTER XIII. Area of the Purgatory River, pp. 193–224.
XIV. Area of the Canadian River, pp. 224–262.
XV. Area of the Mora River, pp. 263–312.
XVI. Area of the Rio Grande, pp. 313–353.

PART IV.—*Economic Geology, Professor Stevenson.*

CHAPTER XVII. Capabilities for settlement, pp. 354–358.
XVIII. Summary of Mineral Resources, pp. 359–406.
APPENDIX. Dr. C. A. White:
Carboniferous Invertebrate Fossils of New Mexico, pp. I to XXXVII.

VOLUME IV.—PALEONTOLOGY.

Introductory Letter, Lieutenant Wheeler.

PART I.—*Dr. C. A. White.*

CHAPTER I. General Observations, pp. 5–20.
II. Classification, pp. 21–31.
III. Fossils, primoidal Period, pp. 32–49.
IV. Fossils, Canadian period, pp. 49–61.
V. Fossils, Trenton period, pp. 62–78.
VI. Fossils, Sub-carboniferous period, pp. 79–95.
VII. Fossils, Carboniferous period, pp. 96–161.
VIII. Fossils, Jurassic period, pp. 162–168.
IX. Cretaceous period, pp. 169–205.
X. Tertiary period, pp. 206–216.

PART II.—*Prof. E. D. Cope.*

CHAPTER XI. Geology of Mesozoic and Tertiary Beds and Mesozoic Fossils, pp. 1–36.
XII. Eocene Fossils, pp. 37–262.
XIII. Fossils of Loup Fork Epoch, pp. 263–365.

VOLUME V.—ZOOLOGY.

Introductory Letter, Lieutenant Wheeler.

CHAPTER I. Geographical Distribution and Variation with regard to the Zoology of the West, relating especially to Mammals and Birds, Dr. H. C. Yarrow, pp. 22–34.
II. Mammals: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; Drs. Coues and Yarrow, pp. 35–129.
III. Birds: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; H. W. Henshaw, pp. 130–507.

CHAPTER IV. Batrachians and Reptiles: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; Dr. Yarrow, pp. 509–584.
V. Reptiles and Batrachians of Arizona: Dr. Coues, pp. 585–633.
VI. Fishes: Nevada, Utah, California, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; Professor Cope and Dr. Yarrow, pp. 635–703.
VII. Hymenoptera: Nevada, Utah, Colorado, New Mexico, and Arizona; 1872, 1873, and 1874; E. T. Cresson; with list of Formicidæ; Edward Norton, pp. 705–735.
VIII. Diurnal Lepidoptera: Colorado, Utah, New Mexico, and Arizona; 1871, 1872, and 1874, with notes upon all species known from Colorado; Theo. L. Mead; and a list of all species collected; W. H. Edwards, pp. 737–794.
IX. New species of Zygænidæ and Bombycidæ: California and Arizona; 1871, 1872, and 1873; R. H. Stretch, pp. 795–802.
X. Diptera: Colorado and Arizona; 1873; C. R. Osten-Sacken, pp. 803–807.
XI. Coleoptera: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; Henry Ulke, pp. 809–827.
XII. Hemiptera: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1873, and 1874; Professor Uhler, pp. 828–842.
XIII. Orthoptera: Nevada, Utah, California, Colorado, New Mexico, and Arizona; 1871, 1872, 1873, and 1874; Professor Thomas, pp. 843–908.
XIV. Neuroptera and Pseudo Neuroptera: Colorado, New Mexico, and Arizona; 1872, 1873, and 1874; Dr. Hagen, pp. 909–922.
XV. Terrestrial and Fluviatile Mollusca: Colorado, Utah, New Mexico, and Arizona; 1872, 1873, and 1874; Dr. Yarrow, pp. 923–954.
XVI. Fresh-water Leeches: 1872, 1873, and 1874; Professor Verrill, pp. 955–967.

VOLUME VI.—BOTANY.

Introductory Letter, Lieutenant Wheeler.

CHAPTER I. Colorado District: Dr. Rothrock, pp. 1–14.
II. New Mexico District: Dr. Rothrock, pp. 15–37.
III. Economic Botany: Dr. Rothrock, pp. 39–52.
IV. Catalogue: Nevada, Utah, Colorado, New Mexico, and Arizona; Dr. Rothrock, and Sereno Watson, George Engleman, Professor Porter, M. S. Bebb, William Boott, George Vasey, Professor Eaton, Thomas P. James, Professor Tuckerman, pp. 53–351.
APPENDIX. California collection: Dr. Rothrock, pp. 353–378.

VOLUME VII.—ARCHÆOLOGY.

Introductory Letter, Lieutenant Wheeler.

PART I.—*Prof. F. W. Putnam.*

(Assisted by C. C. Abbott, M. D., S. S. Haldeman, L. L. D., H. C. Yarrow, M. D., H. W. Henshaw, and Lucien Carr.)

Introduction: General Archæology and Ethnology of Southern California, pp. 1–31; Yarrow's Report on operations of party making collections, pp. 32–45; Collections at Dos Pueblos and La Patera, pp. 46–48; Chipped Stone Implements, pp. 49–69; Stone Mortars, Pestles, Cups, etc., pp. 70–92; Cooking vessels, baking stones, etc., pp. 93–116; Manufacture of soap-stone pots, pp. 117–121; Articles made of wood, pp. 122–124; Stone pipes, pp. 125–134; Perforated stones, pp. 135–189; Miscellaneous articles of stone, pp. 190–217; Sculptures, pp. 218–221; Implements and weapons of bone and wood, pp. 222–233; Musical instruments made of bones, pp. 234–238; Textile fabrics, basket-work, brushes, pp. 239–250; Ornaments and paint, pp. 251–262; Beads, pp. 263–271; Iron implements and other objects, obtained by contact, with Europeans, pp. 272–276; Observations on Crania in California.

APPENDIX to Part I.—Translation of the account of Cabrillo's voyage along the west coast of North America, with introductory notes (H. W. Henshaw), pp. 293–314.

PART II.—*The Pueblo Ruins and the Interior Tribes, Prof. F. W. Putnam.*

Introduction, pp. 315–318; Notes on the Pueblos and their inhabitants, pp. 319–324; The Pueblo of Acoma, pp. 325–326; The Pueblo of Taos, pp. 327–330; The Pueblo of San Juan, pp. 331; The Cachina, a Zuni dance, pp. 332–336; Report on the ruins and Pueblos in New Mexico, pp. 337–345; Ruins in New Mexico, pp. 346–350; Ancient population in northwestern New Mexico, pp. 351–361; Ruined Pueblo and burial place in the Valley of the Rio Chama, pp. 362–365; The Pueblo Pintado and other ruins in the Chaco Cañon, pp. 366–369; Cliff House and cave in New Mexico, pp. 370–371; Ruins in the Cañon de Chelle, pp. 372–373; Notes on the implements, pottery, and other objects from New Mexico and Arizona, pp. 374–390; Notes upon human crania and skeletons, pp, 391–398.

APPENDIX. Linguistics: Albert S. Gatschet; classification of dialects in forty vocabularies, into seven linguistic stocks, pp. 399–423; Comparative tables of forty vocabularies, pp. 424–466. Appendix: Additions to the forty vocabularies.

SYNOPTICAL LIST OF REPORTS AND MAP.

SPECIAL PRELIMINARY AND PROGRESS REPORTS.

I.—*Exploration of 1869.*

Preliminary Report upon a Reconnaissance through Southern and Southeastern Nevada. Washington: Government Printing Office, 1875. (Republished from a royal octavo edition, by order of the Secretary of War. 4°, pp. 72. Original and later edition out of print.)

II.—*Exploration and Survey of 1871.*

Preliminary Report concerning Explorations and Surveys, principally in Nevada and Arizona. Washington: Government Printing Office, 1872. (4°., pp. 96, with map. Out of print.)

III.—*Exploration and Survey of 1872.*

NOTE.—The regular Annual Report of 1872 appears as Appendix D D of the Annual Report of the Chief of Engineers of that year, but was not separately issued.

Progress Report upon Geographical and Geological Explorations and Surveys west of the one hundredth meridian. Washington: Government Printing Office, 1874. (4° pp. 56, with skeleton map and fine plates. Out of print.)

IV.—*Survey of 1873.*

Annual Report upon the Geographical and Geological Surveys and Explorations west of the one hundredth meridian, in Nevada, Utah, Colorado, New Mexico, and Arizona, being Appendix E E, of the Annual Report of the Chief of Engineers for 1873. Washington: Government Printing Office, 1873. (11 pp. 8° with skeleton map. Out of print.)

V.—*Survey of 1874.*

Annual Report of the Geographical Explorations and Surveys west of the one hundredth meridian, in California, Nevada, Arizona, Colorado, New Mexico, Wyoming, and Montana, being Appendix F F of the Annual Report of the Chief of Engineers for 1874. Washington: Government Printing Office, 1874. (130 pp. 8° with progress map. Out of print.)

VI.—*Survey of 1875.*

Annual Report upon the Geographical Explorationb and Surveys west of the one hundredth meridian in California, Nevada, Nebraska, Utah, Arizona, Colorado, New Mexico, Wyoming, and Montana, being Appendix L L of the Annual Report of the Chief of Engineers for 1875. Washington: Government Printing Office, 1875. (196 pp. 8° with progress and triangulation maps of 1875, and thirty-eight illustrations. Out of print.)

VII.—*Survey of* 1876.

Annual Report upon the Geographical Surveys west of the one hundredth meridian, in California Nevada, Utah, Colorado, Wyoming, New Mexico, Arizona, and Montana, being Appendix J J of the Annual Report of the Chief of Engineers for 1876. Washington: Government Printing Office, 1876. (350 pp. 8° with nine large and small folded maps, fifteen illustrations, and seven separately folded topographic atlas sheets, viz, Nos. 61 B, 61 C, 61 C sub, 69 D, 75, 76, and 83. Out of print.)

VIII.—*Survey of* 1877.

Annual Report upon the Geographical Surveys west of the one hundredth meridian, in the States and Territories of California, Oregon, Nevada, Texas, Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming, being Appendix N N of the Annual Report of the Chief of Engineers for 1877. Washington: Government Printing Office, 1877. (133 pp. 8° with progress map, sketch and profile maps of Continental Divide, and sketch of lignitic seams. Also Atlas Sheets Nos. 53 C, 61 B, 61 C sub, 61 D, 65 D, 69 B, 70 A, 70 C, and 77 B, land-classification series.)

NOTE.—This separately printed report follows the paging given to it in the Report of the Chief of Engineers.

IX.—*Survey of* 1878.

Annual Report upon the Geographical Surveys of the territory of the United States west of the one hundredth meridian, in the States and Territories of California, Colorado, Kansas, Nebraska, Nevada, Oregon, Texas, Arizona, Idaho, Montana, New Mexico, Utah, Washington, and Wyoming, being Appendix N N of the Annual Report of the Chief of Engineers for 1878. Washington: Government Printing Office, 1878. (234 pp. 8° with progress map and six illustrations and an early map of California. Out of print.) Also nine separately folded atlas sheets, viz, Nos. 41 B, 47 D, 61 C. 62 A, 62 C, 69 D, 77 D, and 84 B.

X.—*Survey of* 1879.

Annual Report upon the Geographical Surveys of the territory of the United States west of the one hundredth meridian, in the States and Territories of California, Colorado, Kansas, Nebraska, Nevada, Oregon, Texas, Arizona, Idaho, Montana, New Mexico, Utah, Washington, and Wyoming, being Appendix O O of the Annual Report of the Chief of Engineers for 1879. Washington: Government Printing Office, 1879. (335 pp. 8° with progress map and six illustrations.) Also seven separately folded atlas sheets, viz, Nos, 22 D, 47 B, 47 D, 61 D, 73 A, 74 A, and 84 B.

XI.—*Reports of* 1880.

Annual Reports upon the Geographic and Topographic Surveys of the territory of the United States west of the one hundredth meridian, in the States and Territories of California, Colorado, Kansas, Nebraska, Nevada, Oregon, Texas, Arizona Idaho, Montana, New Mexico, Utah, Washington, and Wyoming, being Appendix T T for 1880 (44 pp. 8° with progress map); Appendix V V for 1881 (5 pp. 8° with progress map); Appendix T T for 1882 (4 pp. 8° with progress map); Appendix V V for 1883 (3 pp. 8°); and Appendix V V for 1884 (4 pp. 8°). Washington: Government Printing Office, 1880, 1881, 1882, 1883, and 1884.

QUARTO REPORTS.

VOL. I. Geographical Report (in five chapters, with an introduction and appendixes, illustrated by three maps and thirty-eight plates, 764 pp. 4° and index.) Issued 1889.

VOL. II. Astronomy and Barometric Hypsometry (in two parts, illustrated by twenty-two plates and three wood-cuts, 584 pp. in all. Out of print). Issued 1877.

VOL. III. Geology (in six parts, illustrated by thirteen plates and one hundred and seventy-one wood-cuts, 681 pp. Out of print). Issued 1875.

VOL. III. Geology, supplement (in four parts and an appendix, illustrated by four plates, three maps, and forty-nine cuts, 456 pp.). Issued 1881.

VOL. IV. Paleontology (in two parts, illustrated by eighty-three plates, with explanatory notes, 604 pp. Out of print). Issued 1877.

VOL. V. Zoology (in sixteen chapters, with forty-five plates, and indexes, 1021 pp. Out of print). Issued 1875.

VOL. VI. Botany (in four chapters, with an appendix, thirty plates, and one wood-cut, 424 pp.). Issued 1878.

VOL. VII. Archæology, (in two parts, with two appendixes, illustrated with frontispiece, sketch, twenty plates, and thirty-five cuts, 517 pp.). Issued 1879.

SPECIAL AND MISCELLANEOUS PUBLICATIONS.

Tables of camps, distances, etc. Explorations and Surveys in Nevada and Arizona, 1871. Washington: Government Printing Office, 1872. (Oblong folio, pp. 14. Out of print.)

Tables containing camps, distances, latitudes, longitudes, altitudes, etc. Explorations and Surveys in Utah, Nevada, and Arizona, 1872. Washington, Government Printing Office, 1873. (4°, pp. 43. Out of print.)

Report upon the Determination of the Astronomical Co-ordinates of the Primary Stations at Cheyenne, Wyo., and Colorado Springs, Colo., during 1872 and 1873. Washington: Government Printing Office, 1874. (4°, pp. 82. Out of print.)

Report upon Vertebrate Fossils discovered in New Mexico, with description of new species. Extract from Appendix P P of Annual Report of the Chief of Engineers, 1874. Washington: Government Printing Office, November 28, 1874. (pp. 18, 8°. Out of print.)

NOTE.—This was preliminary to the full report in Part II, Vol. IV, 4° series, Paleontology.

On the Plagopterinæ and Ichthyology of Utah, 1874. (pp. 14, 8°. Out of print.)

NOTE.—This was republished from the Proceedings of the American Philosophical Society of Philadelphia, where the material was first presented by permission of the War Department.

Systematic Catalogue of the Vertebrata of the Eocene of New Mexico, collected in 18 4. Washington: Government Printing Office, April 17, 1875. (pp. 37, 8°. Out of print.)

NOTE.—This report is a second and final part of the preceding one of November 28, 1874. See 4° series, Vol. IV, Part II, Paleontology, for full report.

Preliminary Report upon Invertebrate Fossils, collected by the expeditions of 1871, 1872, and 1873, with description of new species. Washington: Government Printing Office, December, 1874. (pp. 27, 8°. Out of print.)

NOTE.—Preliminary to the full report in Vol. IV, 4° series, Part I, Paleontology.

Catalogue of Plants collected in the years 1871, 1872, and 1873, with descriptions of new species. Washington: Government Printing Office, 1874. (pp. 62, 8°. Out of print.)

NOTE.—Preliminary to full report in Vol. VI, Botany.

Report upon Ornithological Specimens collected in 1871, 1872, and 1873. Washington: Government Printing Office. (pp. 148, 8°. Out of print.)

NOTE.—Preliminary to the full report in Vol. V, Zoology, 4° series; also a List of Birds of Utah, with annotations by Mr. Henshaw, appended. From the Annals of the Lyceum of Natural History of New York, Vol. XI, June, 1874.

Logarithm, Traverse, and Altitude Tables. Washington: Government Printing Office, 1875. (pp. 20, 8°. Out of print.)

Instructions for taking and recording Meteorological Observations, etc., prepared for use of parties of Geographical Survey west of the one hundredth meridian, with Barometric Tables I to XI, inclusive, of Professional Papers, Corps of Engineers, No. 15, appended. Washington: Government Printing Office, 1875. (pp. 64, 8°. Out of print.)

NOTE.—The above is a revision of similar "Instructions" issued in 1874, in pamphlet form, 12mo.

Barometric Hypsometry Instructions. (1876.) Washington: Government Printing Office, 1876. (8°, pp. 88. Out of print.)

NOTE.—This is a revised edition of the preceding.

Catalogue of Mean Declination of 2,014 Stars, for January 1, 1875. Washington: Government Printing Office, 1877. (4°, pp. 207.)

List of Longitudes, Latitudes, and Altitudes, being an extract from Vol. II, 4° series (pp. 22, with blank tables; office edition).

Field List of Time Stars, etc. (1878.) Washington: Government Printing Office, 1878. (8°, pp. 13.)

Note.—The inside heading of this pamphlet is: "List of 278 Time Stars and 63 Circumpolars, for use of," etc.

List of Reports and Maps of the United States Geographical Surveys west of the One Hundredth Meridian. Washington: Government Printing Office, 1878. (8°, pp. 36. Out of print.)

Note.—This pamphlet contains the title and table of contents of book and pamphlet publications of the survey and a reference to each map published or in progress.

List of Reports and Maps, etc. 2d edition. Washington: Government Printing Office, 1881. (8°, pp. 74. Revised edition of the preceding, with progress map. Out of print.)

Tables of Geographic Positions, Azimuths, and Distances, with Lists of Altitudes, Magnetic Declinations, and Itineraries. (1883.) Washington: Government Printing Office, 1885. (Royal 8°, pp. 261.)

Note.—Prior to the completion of the final reports of the survey the report by Captain Wheeler, commissioner, etc., on the Third International Geographical Congress and Exhibition, accompanied by facts concerning the principal Government land and marine surveys of the world, appeared as House Ex. Doc. No. 270, Forty-eighth Congress, second session (1 vol. 4°, pp. 586, with eleven maps and plates).

Independently of the foregoing publications, the direct requirement of the operations and results of the survey, the following Congressional documents bear on this work:

1. House Ex. Doc. No. 271, Forty-third Congress, first session. Extra cost for 1873.
2. House Ex. Doc. No. 240, Forty-third Congress, first session. (1874.) Special message of President Grant, transmitting reports on geographical and geological surveys west of the Mississippi.
3. Report No. 612, House of Representatives, Forty-third Congress, first session. (1874.) From Committee on Public Lands regarding geographical and geological surveys west of the Mississippi.
4. House Ex. Doc. No. 32, Forty-third Congress, second session. (1874). "Printing report of Lieutenant Wheeler's expedition."
5. House Ex. Doc. No. 109, Forty-third Congress, second session. "Lieutenant Wheeler's Geographical Surveys," inclosing complimentary letter of Field Marshal General, the Count von Moltke.
6. House Report 149, Forty-third Congress, second session. (1874.) Contains disclaimer of Yale College Faculty concerning geographical and geological surveys west of the Mississippi.
7. House Ex. Doc. No. 81, Forty-fifth Congress, second session. (1878.) Letter from Secretary of Interior transmitting statement of Prof. F. V. Hayden, on geological and geographical surveys west of the Mississippi.
8. House Ex. Doc. No. 80, Forty-fifth Congress, second session. (1878.) Letter from Secretary of Interior transmitting statement of J. W. Powell, on "geological and geographical surveys" west of Mississippi.
9. House Ex. Doc. No. 88, Forty-fifth Congress, second session. (1878.) Letter from Secretary of War, transmitting statement by the Chief of Engineers on "Surveys by the War Department," inclusive, the geological exploration of the fortieth parallel, geographical surveys west of one hundredth meridian, and explorations and reconnaissances at headquarters military division and departments. (Contains list of publications.)
10. House Mis. Doc. No. 55, Forty-fifth Congress, second session. (1878.) Testimony before Committee on Public Lands, regarding a *so-called* geodetic system of subdivision for the Public Land Survey.
11. Views of the War Department concerning the public surveys of the Territories of the United States, being Appendix N N, Annual Report of the Chief of Engineers, 1878.
12. Senate Mis. Doc. No. 49, Forty-fifth Congress, third session. (1878). Report of a committee of the National Academy of Sciences, on the "Scientific Surveys of the Territories." (House Mis. Doc. No. 5, Forty-fifth Congress, third session) is the same, with added communications from the Chief of Engineers, Commissioner of the General Land Office, and Messrs. Hayden and Powell.)

13. Senate Ex. Doc. No. 21, Forty-fifth Congress, third session, parts 1 and 2. (1879). Information from War Department concerning surveys west of the Mississippi. Statement from Chief of Geographical Surveys, on extent, methods, cost, and cost of completion of those surveys, and views on report of a committee of the National Academy of Sciences.

14. House Doc. No. 72, Forty-fifth Congress, third session. (1879.) Letter of J. W. Powell, on cost of geographical surveys.

15. House Ex. Doc. No. 164, Forty-fifth Congress, third session. (1879). Statement regarding total cost of geographical surveys west of the one hundredth meridian.

16. Senate Ex. Doc. No. 180, Forty-sixth Congress, second session. Letter of Secretary of War.

17. Senate Ex. Doc. No. 118, Forty-sixth Congress, second session. (1880). Letter from Secretary of War presenting the importance of geographical and topographical surveys of the territory of the United States west of the Mississippi River.

18. Senate Mis. Doc. No. 82, Forty-ninth Congress, first session. (1886). Testimony before the Joint Congressional Commission on Surveys.

19. Senate Report No. 1285, parts 1 and 2, Forty-ninth Congress, first session. (1886.) Report of the Joint Commission on Surveys. The same appears as House Report No. 2740, Forty-ninth Congress, first session.

20. Printed catalogues of maps, reports, and photographs exhibited at the Centennial, and also at the Third International Geographical Congress at Venice, 1881; includes principal publications at date of issue.

SYNOPTICAL LIST OF MAPS.

A.—TOPOGRAPHICAL ATLAS.

I. Title. II. Legend sheet. III. Index map. IV. Basin map. V. Sheet of conventional signs, and the following atlas sheets:

Running No.	Atlas sheet No.	Locality.	Scale of 1 inch to—	Area.	Boundaries. Latitude north.	Boundaries. Longitude west from Greenwich.	Remarks.
			Miles.	Sq. miles.	° ′	° ′ ″	
1	49	Parts of Eastern Nevada and Western Utah	8	16,816	39 00 40 40	112 45 00 115 30 00	Also in crayon.
2	50	Parts of Central and Western Utah	8	16,816	39 00 40 40	110 00 00 112 45 00	Do.
3	57	Parts of Southwestern Nevada and Eastern California	8	17,280	37 20 39 00	115 30 00 118 15 00	
4	58	Parts of Eastern and Southeastern Nevada and Southern Utah	8	17,280	37 20 39 00	112 45 00 115 30 00	Also in crayon.
5	59	Southwestern Utah	8	17,280	37 20 39 00	110 00 00 112 45 00	Do.
6	65	Parts of Southwestern California and Southwestern Nevada	8	17,[illegible]	35 40 37 20	115 30 00 118 15 00	
7	66	Parts of Southeastern California and Southwestern Nevada, Northwestern Arizona, and Southwestern Utah	8	17,[illegible]	35 40 37 20	112 45 00 115 30 00	Also in crayon.
8	67	Parts of Northern Arizona and Southern Utah	8	17,[illegible]	35 40 37 20	110 00 00 112 45 00	Do.
9	69	Parts of Southern Colorado and Northern New Mexico	8	17,[illegible]	35 40 37 20	104 30 00 107 15 00	
10	73	Parts of Southern California	8	17,[illegible]	34 00 35 40	115 30 00 118 15 00	
11	75	Parts of Central and Western Arizona	8	17,[illegible]	34 00 35 40	110 00 00 112 45 00	
12	76	Parts of Eastern Arizona and Western New Mexico	8	17,[illegible]	34 00 35 40	107 15 00 110 00 00	
13	77	Central New Mexico	8	17,[illegible]	34 00 35 40	104 30 00 107 15 00	Also with land classification.
14	83	Parts of Eastern and Southern Arizona and Western and Southwestern New Mexico	8	18,[illegible]	32 20 34 00	107 15 00 110 00 00	
15	84	Part of Southern New Mexico	8	18,[illegible]	32 20 34 00	104 30 00 107 15 00	Also with land classification.
16	32 C	Parts of Southern Idaho	8	4,[illegible]	[illegible] 30 [illegible] 30	112 [illegible] 00 113 45 00	Do.

Running No.	Atlas sheet No.	Locality.	Scale of 1 inch to—	Area.	Boundaries.					Remarks.
					Latitude north.		Longitude west from Greenwich.			
			Miles	Sq. miles.	°	′	°	′	″	
17	32D	Parts of Southeastern Idaho	4	4,023	42 43	20 10	111 112	00 22	00 30	Also with land classification.
18	38 B	Parts of Southern Oregon, Northwestern Nevada, and Northeastern California	4	4,075	41 42	30 20	119 120	15 37	00 30	
19	38D	Parts of Eastern California and Western Nevada	4	4,127	40 41	40 30	119 120	15 37	00 30	Also with land classification.
20	41A	Parts of Southeastern Idaho and Northwestern Utah	4	4,075	41 42	30 20	112 113	22 45	30 00	Do.
21	41 B	Southeastern corner of Idaho and part of Northern Utah	4	4,075	41 42	30 20	111 112	00 22	00 30	Do.
22	47A	Part of Northern California	4	4,178	39 40	50 40	120 122	37 00	30 00	Do.
23	47 B	Parts of Eastern California and Western Nevada	4	4,178	39 40	50 40	119 120	15 37	00 30	In outline and hachures; also with land classification.
24	47 D	Do	4	4,229	39 39	00 50	119 120	15 37	00 30	Do.
25	48C	Part of West Central Nevada	4	4,229	39 39	00 50	117 119	52 15	30 00	
26	48D	Part of Central Nevada	4	4,229	39 39	00 50	116 117	30 52	00 30	
27	53D	Part of Central Colorado	4	4,229	39 39	00 50	105 106	30 52	00 30	Also with land classification.
28	54C	Do	4	4,229	39 39	00 50	104 105	07 30	30 00	
29	56B	Parts of Eastern California and Western Nevada	4	4,278	38 39	10 00	119 120	15 37	00 30	
30	56D	Part of Central California	4	4,328	37 38	20 10	119 120	15 37	00 30	
31	61A	Part of Western Colorado	4	4,278	38 39	10 00	106 108	52 15	30 00	In contours and hachures; also with land classification.
32	61 B	Central Colorado	4	4,278	38 39	10 00	105 106	30 52	00 30	Also with land classification.
33	61 C	Part of Southwestern Colorado	4	4,328	37 38	20 10	106 108	52 15	30 00	In outline and hachures; also with land classification.
34	61 C	Southwestern Colorado, San Juan Mining Region	2	1,100	37 38	42 11	107 107	15 37	00 00	Engraved colored contours showing timber lines, etc.
35	61D	Part of Southern Colorado	4	4,328	37 38	20 10	105 106	30 52	00 30	Also with land classification.
36	62A	Part of Central Colorado	4	4,278	38 39	10 00	104 105	07 30	30 00	Do.
37	62C	Part of Southern Colorado	4	4,328	37 38	20 10	104 105	07 30	30 00	Do.

Running No.	Atlas sheet No.	Locality.	Scale of 1 inch.	Area.	Boundaries.		Remarks.
					Latitude north.	Longitude west from Greenwich.	
			Miles.	Sq. miles.	° ′	° ′ ″	
38	61 D	Part of Southwestern Colorado	4	4,374	37 30 38 20	108 45 00 107 22 30	
39	65 D	Part of Southeastern California	4	4,420	36 40 35 50	116 30 00 117 52 30	Also with land classification.
40	69 B	Parts of Southern Colorado and Northern New Mexico	4	4,374	38 20 37 30	105 00 00 106 22 30	Do.
41	69 D	Part of North Central New Mexico	4	4,420	36 40 35 50	105 00 00 106 22 30	Do.
42	70 A	Parts of Southern Colorado and Northern New Mexico	4	4,374	38 20 37 30	104 07 30 105 30 00	Do.
43	70 C	Part of North Central New Mexico	4	4,420	36 40 35 50	104 07 30 105 30 00	Do.
44	73 A	Part of Southern California	4	4,465	34 50 35 40	117 22 30 118 45 00	Do.
45	73 C	Do	4	4,510	34 00 34 50	117 22 30 118 45 00	Do.
46	77 B	Part of Central New Mexico	4	4,465	34 50 35 40	105 30 00 106 52 30	Do.
47	77 D	Do	4	4,510	34 00 34 50	105 30 00 106 52 30	Do.
48	78 A	Part of Northern New Mexico	4	4,465	34 50 35 40	104 07 30 105 30 00	Do.
49	84 B	Part of Central New Mexico	4	4,554	33 10 34 00	105 30 00 106 52 30	Do.
50	84 C	Part of Southwestern New Mexico	4	4,597	32 20 33 10	106 52 30 108 15 00	Do.

B.—GEOLOGICAL ATLAS.

I. Title. II. Index map. III. Map showing restored outline of Lake Bonneville.

Running No.	Atlas sheet No.	Locality.	Scale of 1 inch to—	Area.	Boundaries.		Remarks.
					Latitude north.	Longitude west from Greenwich.	
			Miles.	Sq. miles.	° ′	° ′ ″	
1	50	Parts of Central and Western Utah	8	26,816	38 00 40 40	111 30 00 113 45 00	Hill-shading in crayon.
2	58 (part) 66 (part)	Parts of Eastern Nevada and Western Utah Part of Southern Nevada	8 8	…… ……	37 30 39 00 36 40 37 30	112 45 00 114 30 40 113 45 00 114 48 40	Do. Do.
3	59	Southwestern Utah	8	17,200	37 20 39 00	111 00 00 113 45 00	Do.
4	67	Parts of Northern Arizona and Southern Utah	8	17,560	35 40 37 30	111 00 00 113 45 00	Do.
5	75	Parts of Central and Western Arizona	8	17,982	34 00 35 40	111 30 00 113 45 00	Hill-shading in h chures.
6	76	Parts of Eastern Arizona and Western New Mexico	8	17,906	34 00 35 40	108 15 00 111 00 00	Do.
7	83	Do	8	18,260	32 20 34 00	106 30 00 109 15 00	Do.
8	70 A	Parts of Southern Colorado and Northern Mexico	4	4,274	36 30 37 30	104 07 30 105 30 00	Do.
9	70 C	Part of North Central New Mexico	4	4,450	35 40 36 30	104 07 30 105 30 00	Do.
10	69 B (part) 69 D (part) 77 B (part) 78 A (part)	Parts of Southern Colorado and Northern New Mexico	4	……	36 35 37 30 35 40 36 04 35 30 34 15 35 10	105 30 00 105 35 30 105 30 00 105 57 41 109 40 45 106 05 00 106 15 00	Do. Do. Do. Do.

C.—SPECIAL MAPS.

1. Map of Reconnaissance through Southern and Southeastern Nevada; scale 1 inch to 12 miles; issued 1869.
2. Outline Map of Washoe District, Nevada; scale 1 inch to 2,000 feet; issued 1879.
3. Topographic Map of Washoe Mining Region, Nevada; scale 1 inch to 1,500 feet; issued 1879.
4. Topographic Map of Parts of Eastern California and Western Nevada, in the vicinity of Tahoe, Pyramid, Winnemucca, and Honey Lakes; scale 1 inch to 4 miles; area 8,632.5 square miles; boundaries, 38° 55′ and 40° 40′ north latitude, and 119° 15′ 00″ and 120° 37′ 30″ longitude west from Greenwich; also with land classification; issued 1879.
5. Outline Map of Southwestern New Mexico; scale 1 inch to 10 miles; issued 1880.
6. Topographic Map of Lake Tahoe region, Nevada and California; photolithographic edition, 1881; scale ½ inch to 1 mile; Heliogravure edition, 1883; scale 1 inch to 2 miles.
7. Outline Map of a Reconnaissance through Central Oregon; scale 1 inch to 8 miles.
8. Topographic Map of the Yosemite Valley and vicinity; scale 3 inches to 2 miles, or 1 to 42,240. Boundaries, 37° 40′ 15″ to 37° 47′ 00″ north latitude, and 119° 29′ 15″ to 119° 42′ 00″ longitude west from Greenwich.

APPENDIX H.

GEOGRAPHIC-TOPOGRAPHIC SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN.

INTRODUCTORY.

This work consisted of a mathematically based topographic survey, intended as a connected first survey of a comparatively wild and uninhabited region, more particularly for immediate military purposes at a minimum of time and cost, and serves as a model wherever like conditions shall arise. It is not suited to thickly settled territory, with well developed communications and industries, where more detail would be required and where a larger *pro rata* of established latitudes and longitudes of the first order, and other topographic data, should be made available.

ORIGIN.

Its origin was the outgrowth of a permanent and legitimate want of the War Department for current topographic information of the vast area west of the Mississippi, within which constant military movements were and are required. It was in a measure a continuation of such disconnected topographic works as the War Department had begun to prosecute for special objects prior to the war of the rebellion, and which were resumed at the headquarters of the military divisions and departments at the close thereof. It added to all existing data a complete survey commencing with initial astronomic and geodetic points, with added topographic and hypsometric details upon which the orographic chart was based, thus forming a connected detail map of the region, suitable for all purposes for not less than fifty years.

ORGANIZATION.

Its personnel consisted of officers of Engineers, of the line of the Army, medical officers, those in command of escorts, and soldiers where required, certain astronomers, civilian assistants, with technical office officials, selected Engineer soldiers, etc; in short, a combination of military and civilian talent suited to the needs of the service and calculated to produce, with rapidity and economy, the results demanded.

ADMINISTRATION.

The officer in charge reported directly to the Chief of Engineers, where the annual projects were approved as well as by the Secretary of War. These operations were pursuant to partial money grants, based on an original project for a complete and connected detail survey and map of the whole area in fifteen years, at a cost not exceeding $2,500,000.

Its administration, like that of all interior topographic works of the Government from its organization to the year 1879, and especially since 1819, was in the War Department.

It ceased simply from want of appropriations, but not so the want that determined its existence.

FUNCTIONS.

Its functions are partially set forth in letter of instructions of the Chief of Engineers, dated March 3, 1871, modified by methods suggested from time to time by the officer in charge in regard to the geodetic net or ground work for the maps as well as the perfection of interior topographic details. The subjects of geology, mineralogy, zoology, etc., incidentally received attention directly and in connection with the large collections made by specialists and others in these branches, which became the property of the Government, and the examination of which led to extended monographic reports in the branches under observation. While the jurisdiction actually named for the field work embraced only the area west of the one-hundredth meridian (an arbitrary line), yet from the first assignment of the officer in charge in February, 1871, he had been instructed to prepare himself for the investigation of the subject of surveys and explorations in the interior (see Special Order 25 Headquarters Chief of Engineers, February 28, 1871) as a general duty, which was prosecuted as circumstances permitted, from which resulted the data upon which to base a project for a complete connected topographic survey of the whole United States. (See chapter on Government surveys).

The great general survey of the country, thus outlined, is a subject of the utmost importance; which, when once done, the initial or primal value becomes enhanced by time, and when sufficiently developed meets all the requirements of commerce and scientific investigation, results from which are considered so necessary that specified resurveys are constantly made, always with increasing detail, by the several European Governments.

HISTORY.

This work closed its field labors in 1879, its office on February 29, 1884, and the present volume is the last of its publications.

The cost for field and office work, including all expenses from the supply branches of the Army, with each and every expenditure chargeable to the work, was $691,444.45.* This sum has been reached after the most careful personal examination and much labor, and is an abstract from the actual vouchers of expenditure in all cases except the Quartermaster's Department, and is complete and final, notwithstanding any and all statements to the contrary from other sources.

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* This does not include the sum of $67,083.14, the total paid for engraving and printing maps and illustrations for reports, or that of $95,129.11, the total of salaries to Army officers from commencement to the close of the office, March 1, 1884, since which no expenditure has been made. The former does not at all increase the volume or character of results, and the officers being in regular commission must have been paid whether engaged on this or other duty, and it has been invariably held that such expenditure is not properly chargeable to the special work under the War Department. Credit is due for money turned into the Treasury from sales ($6,498.45) and for estimated value of instruments and property ($57,000) at close of field work. References to the cost of this work will be found in House Ex. Doc. 88, Forty-fifth Congress, second session, May 10, 1878; House Ex. Doc. 104, Forty fifth Congress, third session, February 24, 1879; House Ex. Doc. 270, Forty-eighth Congress, second session, pp. 473 and 486, December 10, 1883; and Senate Report 1285, Forty-ninth Congress, first session, June 8, 1886.

METHODS, PROGRESS, AND RESULTS.

The methods are found described in Appendix C of this report.

The progress and results are summarily stated in Appendix F (this volume).

The publications, consisting of forty-one separately printed reports and one hundred and sixty-four maps, are now completed, so far as means permit, and this volume is intended to make the references throughout between volumes and maps, and *vice versa*, as connected and complete as possible for convenience of reference.

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